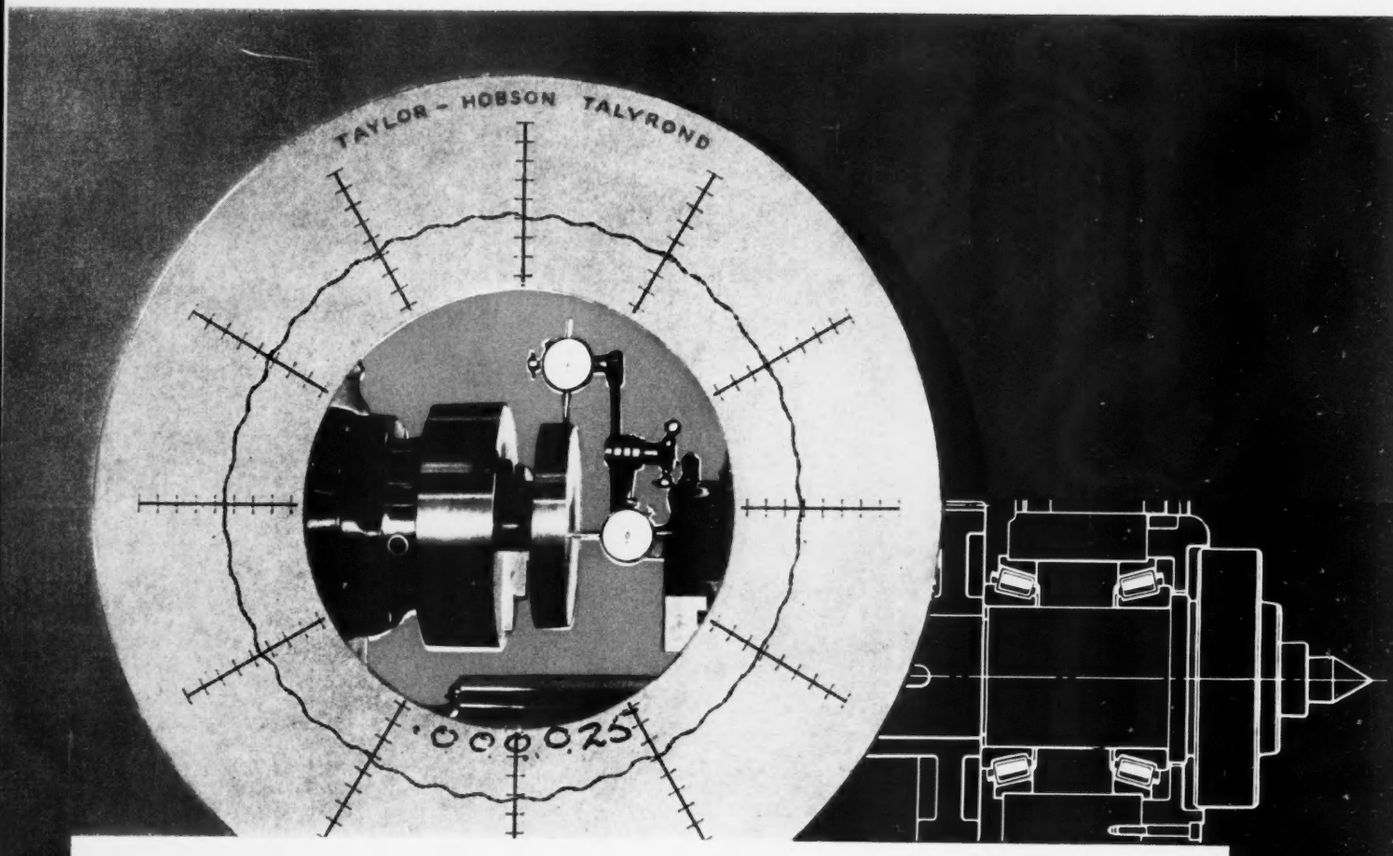
THE ENGINEER

APRIL 15, 1960 | 28, ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS



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NO. 18 HOLBROOK LATHE;

the graph shows an enlarged Talyrond record, indicating the maximum out-of-round as ·000025", the limit for this lathe being ·0001". The 'camming' on the face was also ·000025"; other tests show comparable accuracy. These results are representative, the lathe being typical of the standard production. Full particulars of the three grades of Timken precision bearings, on request. British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

Photograph by courtesy of Holbrook Machine Tool Co. Ltd., Harlow, Essex. Graph taken on Taylor-Hobson Talyrond. Sectional drawing shows the flanged Timken bearings on the front end of the work spindle: these bearings control the axial location in both directions.

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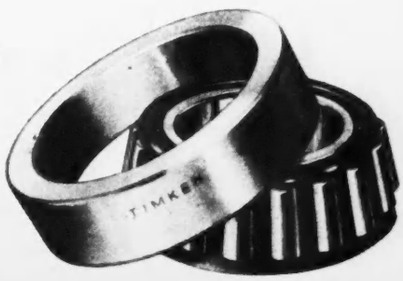

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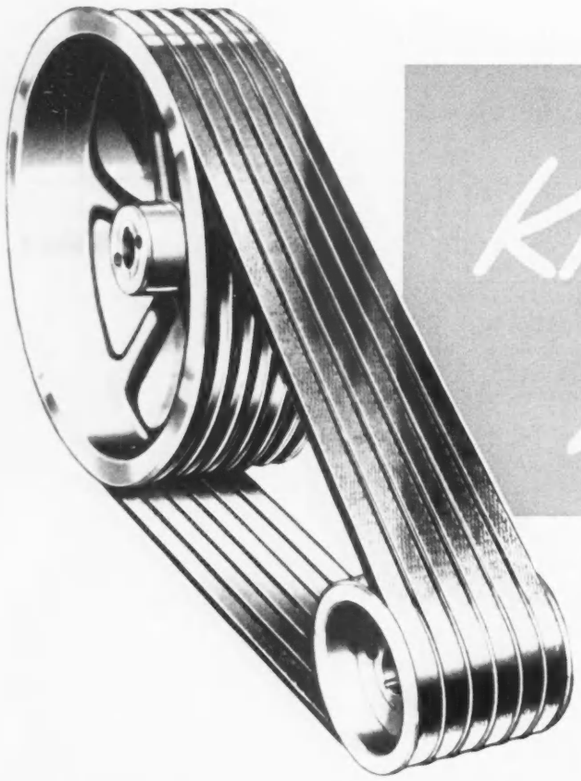

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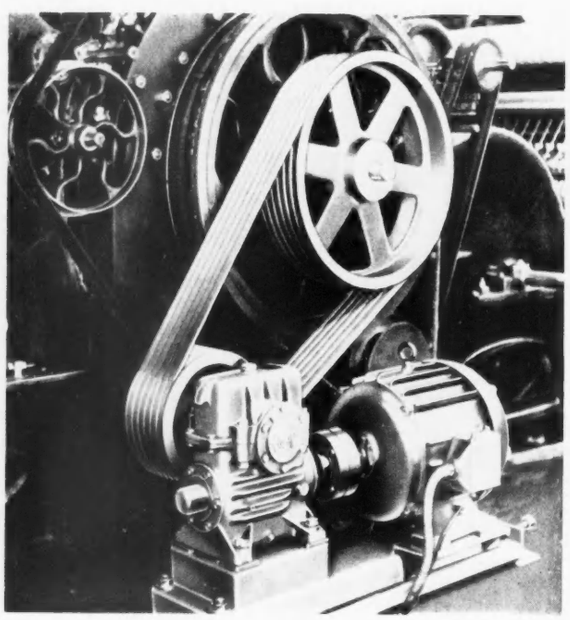

Illustration on right shows Drive to Carding Machine in textile mill incorporating Crofts Radiation Worm Reduction Gear.

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No. 5438 **APRIL 15, 1960** VOL. 209

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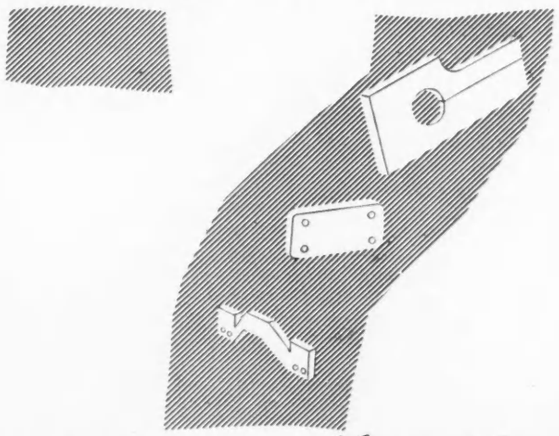

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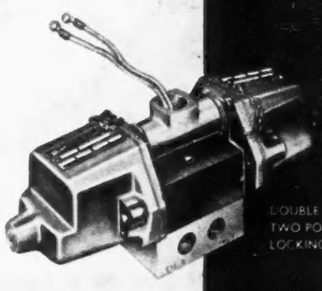

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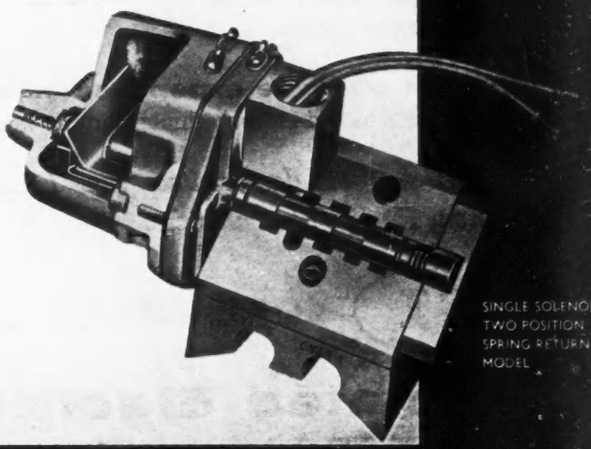

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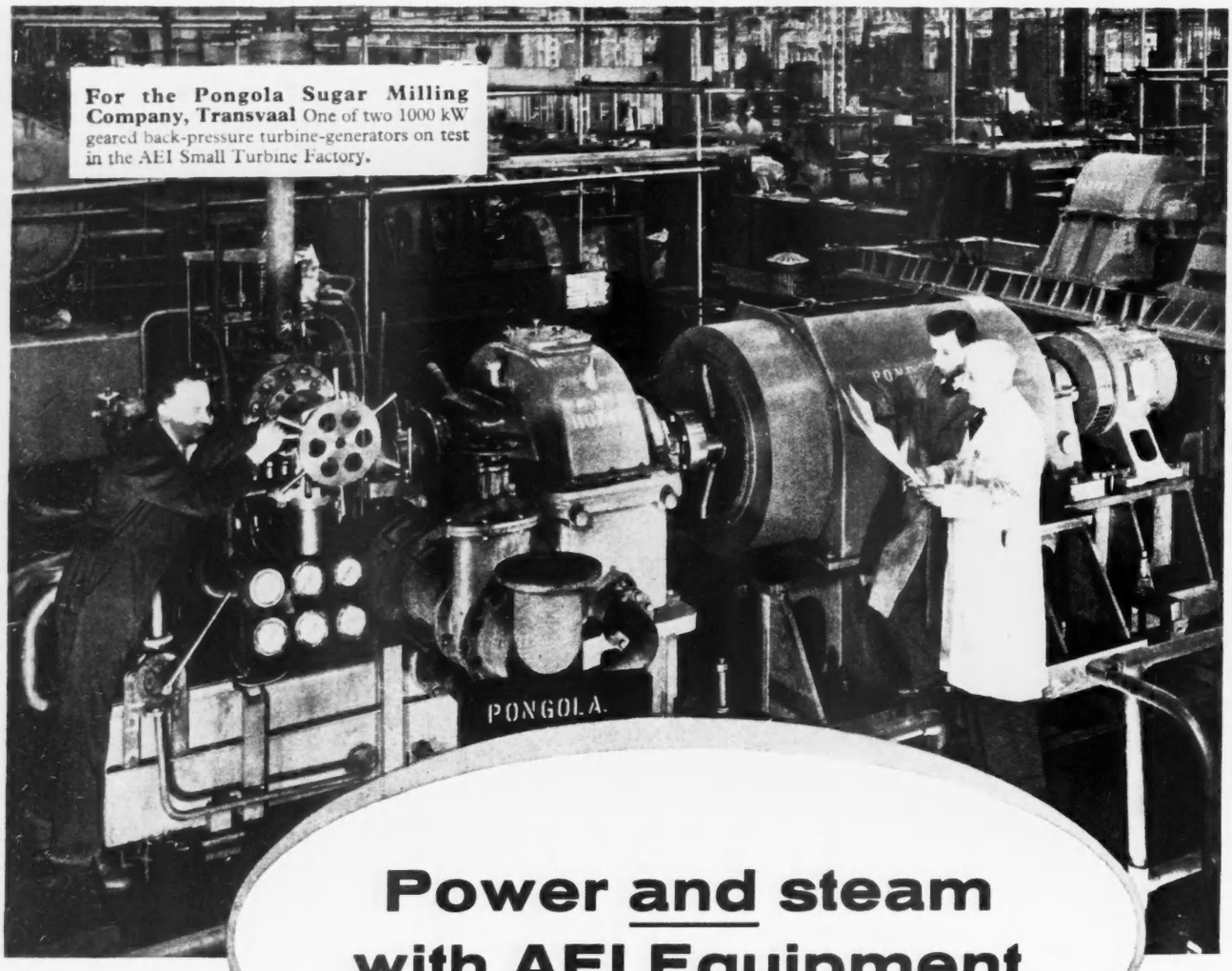

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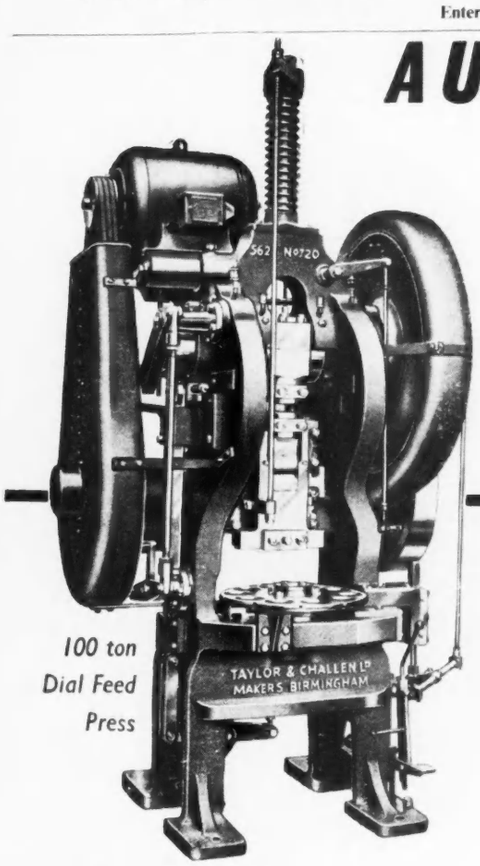

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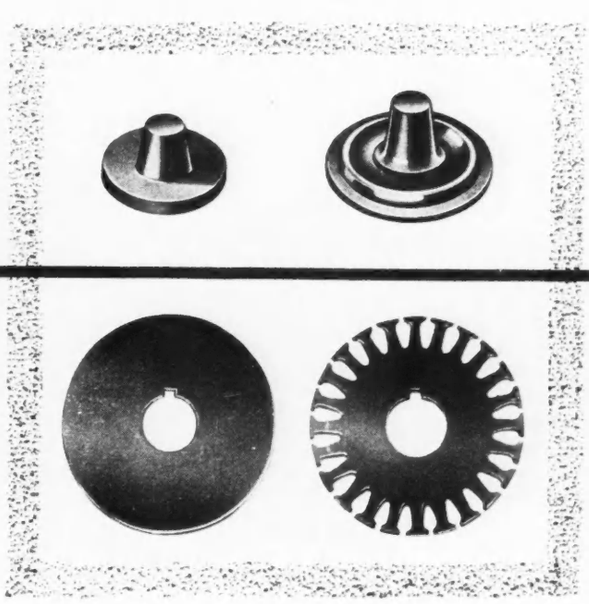

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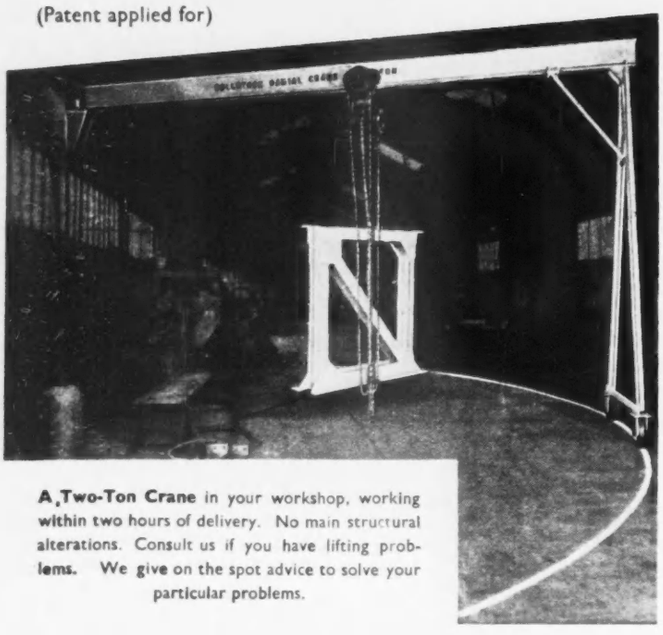

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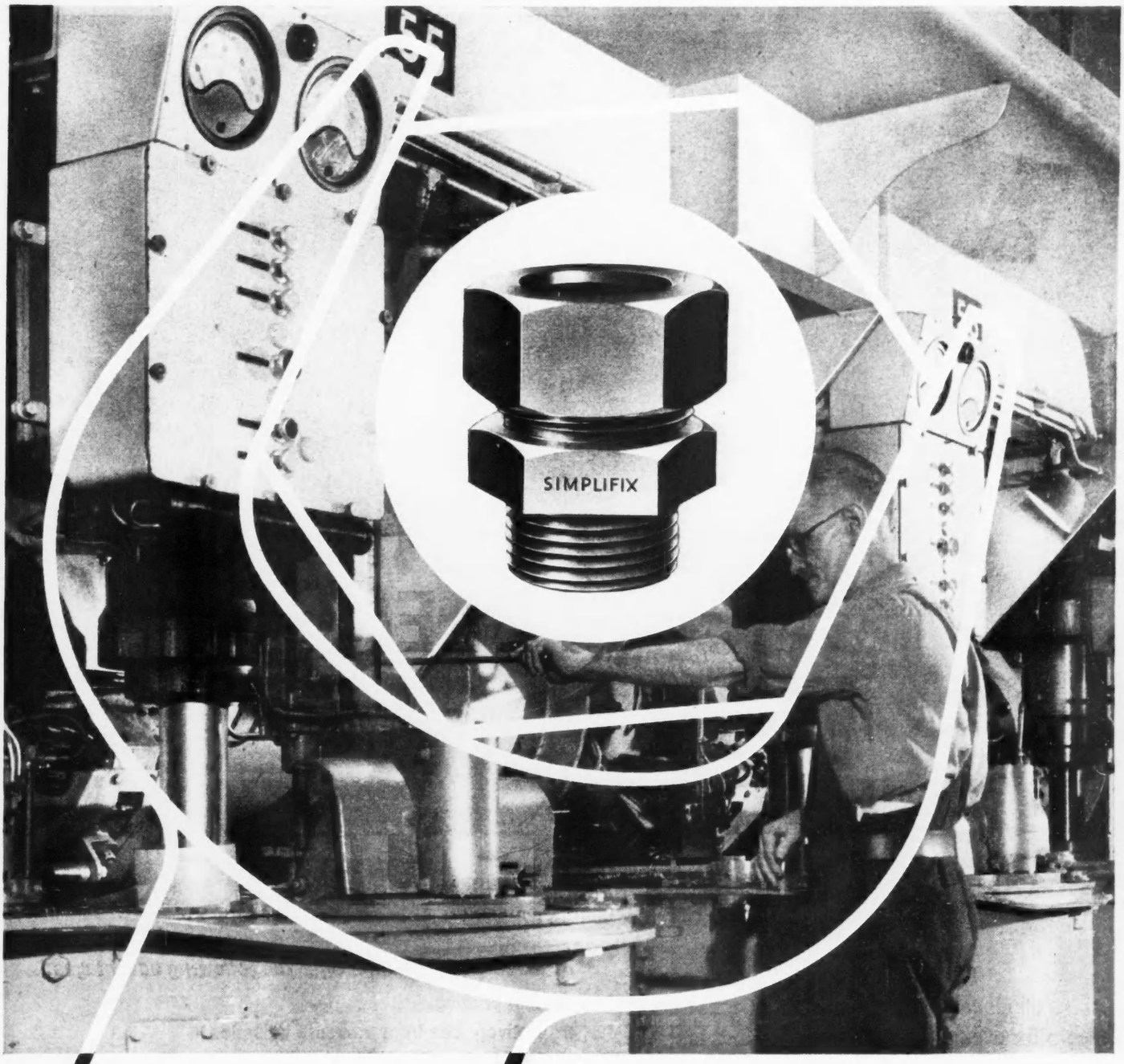

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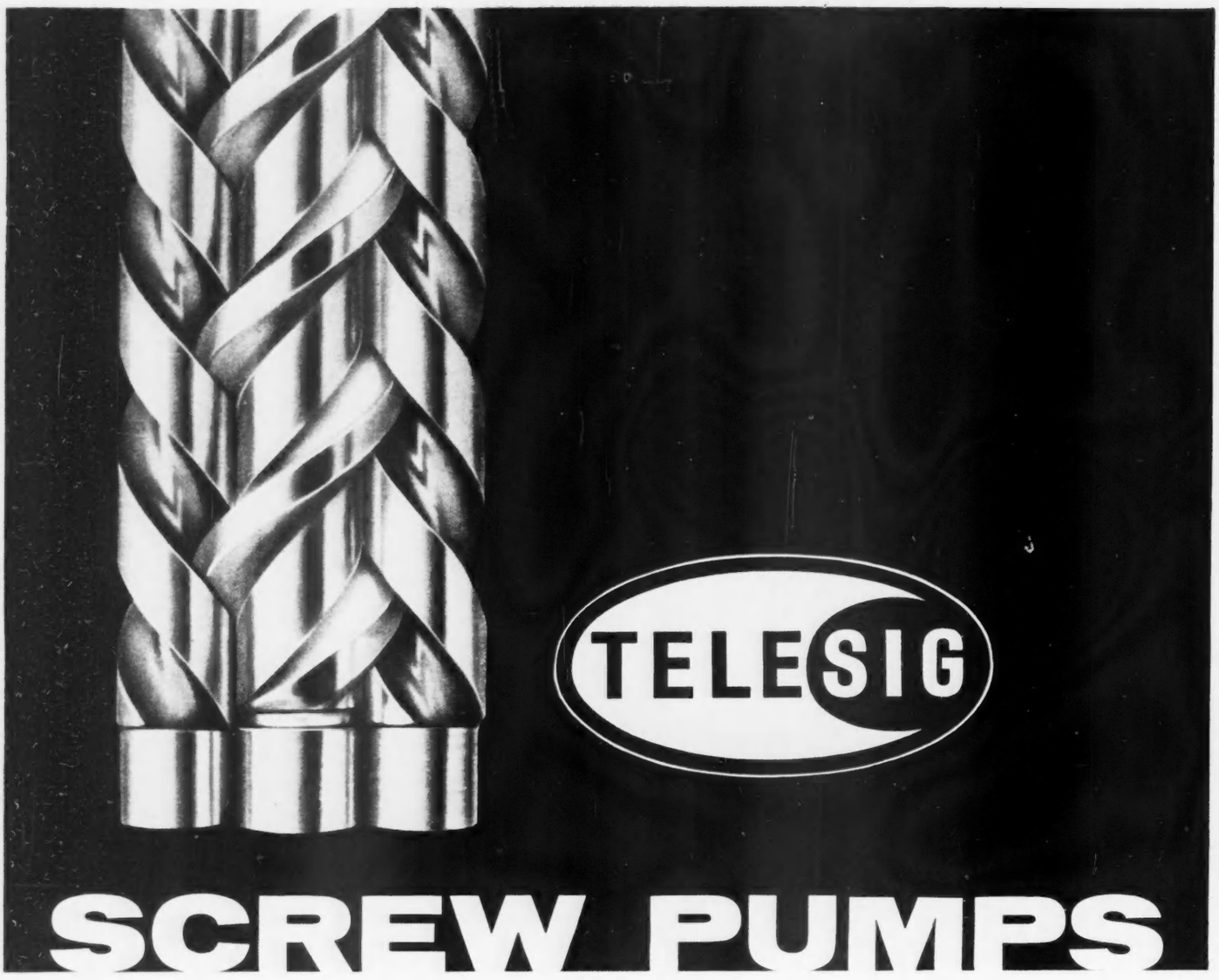

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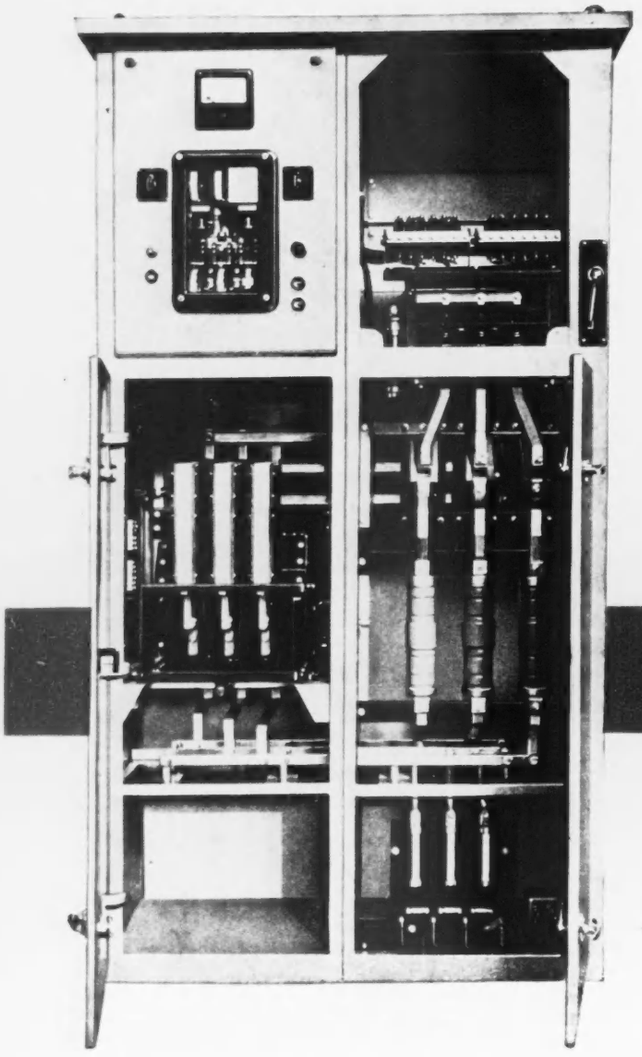

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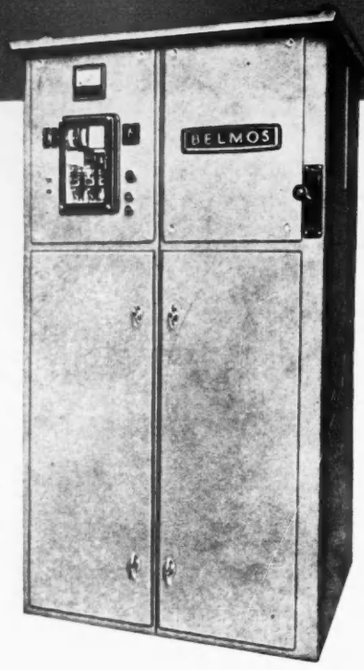

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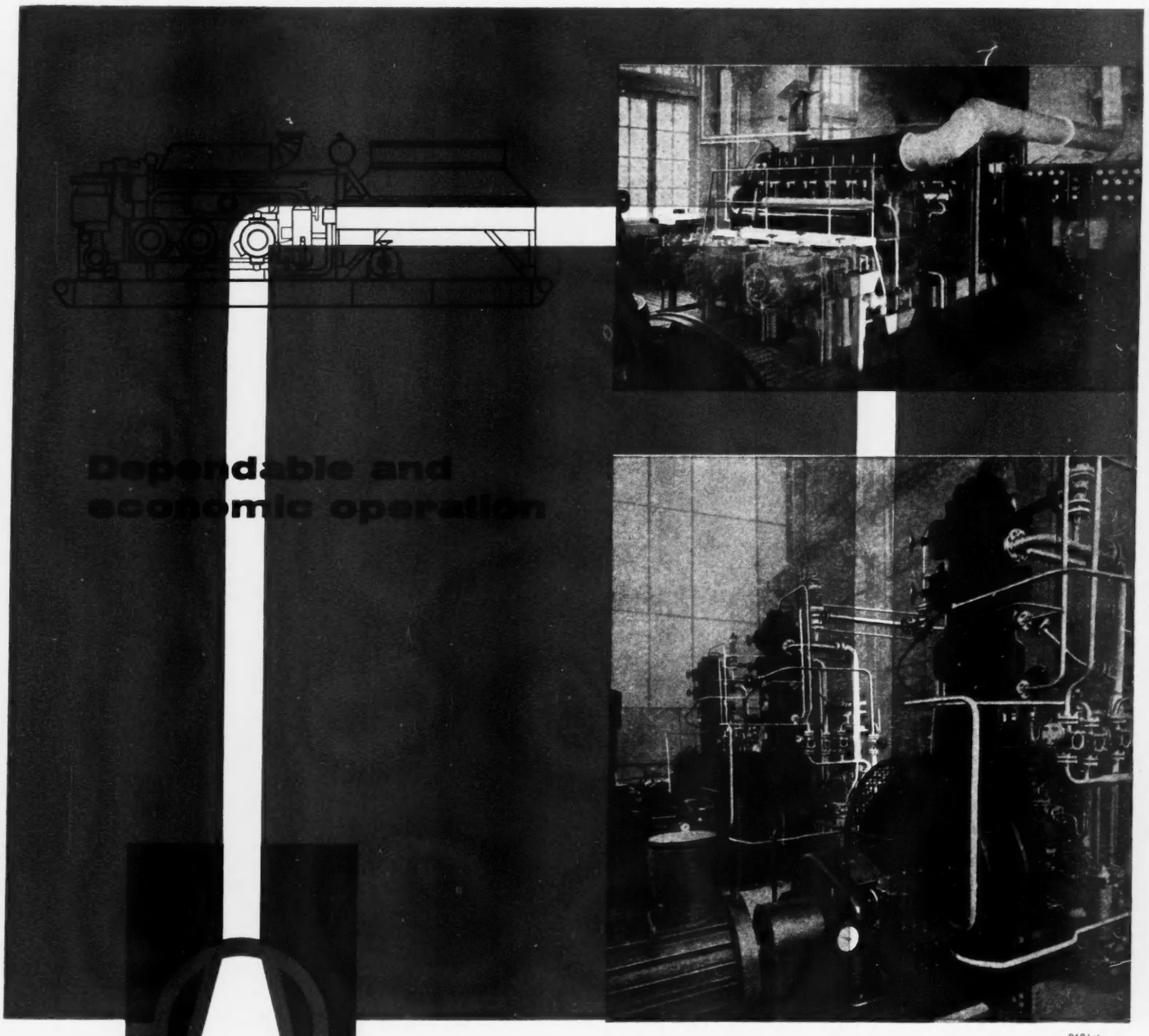

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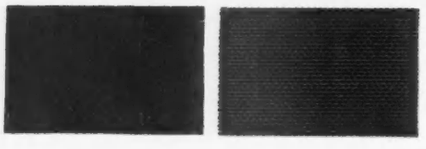

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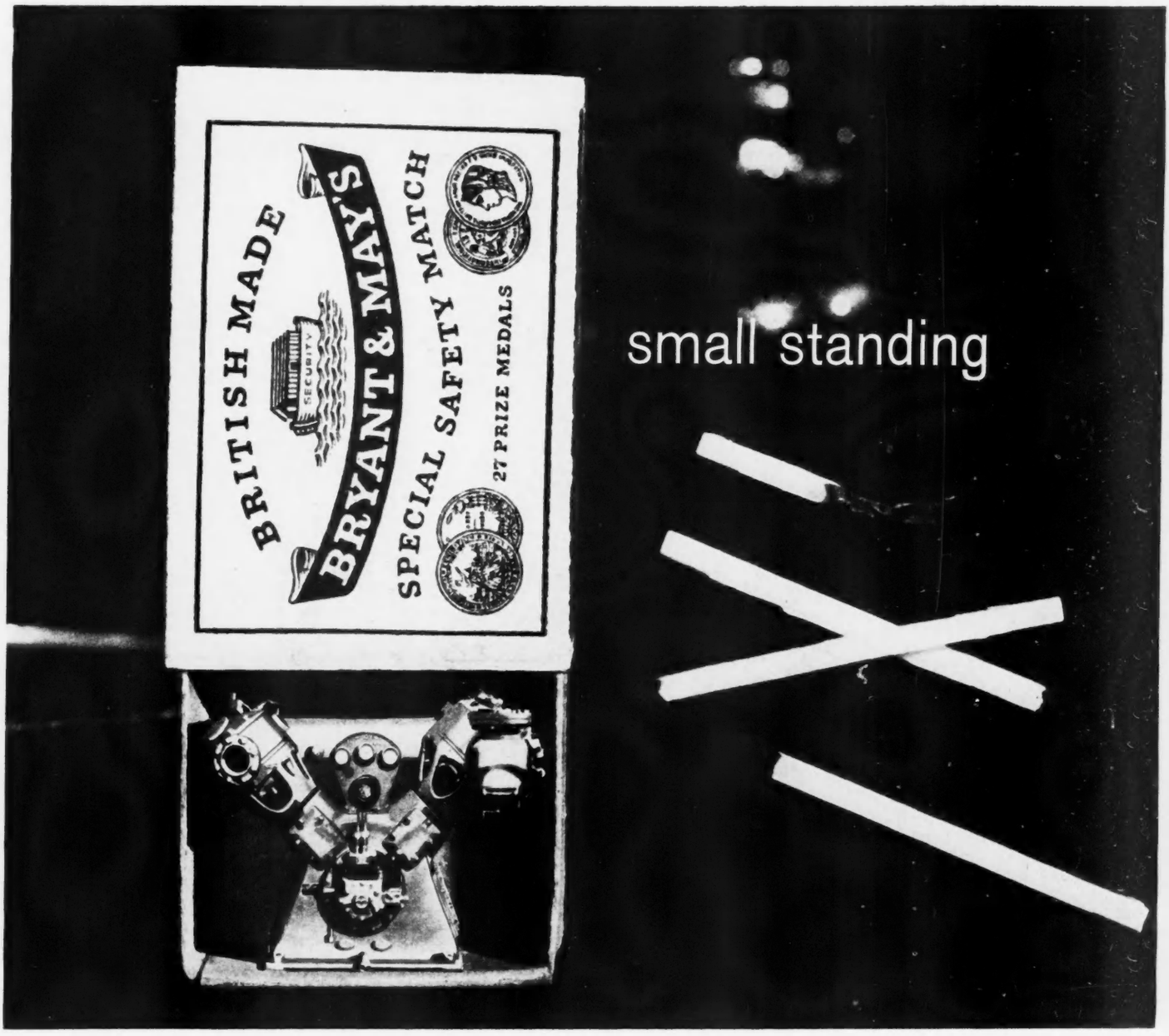

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. . . because Ferodo have a sound answer to every friction problem—from small linings for aircraft instrument clutches to huge overload clutch facings for an icebreaker propeller shaft.
. . . because Ferodo products promise longer life—smoother braking, transmission and control—and the backing of the greatest research and development organisation of its kind in the world.

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Brake Linings · Disc Brake Pads
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Metal sawing problems?

Cold sawing machines are our speciality whether for ferrous, non-ferrous or difficult metals and we have an extensive range of standard machines which cut quickly – and accurately.
We also build machines for special applications.
If you have a cold sawing problem our experience could probably provide the solution. May we help you?

METAL SAWING & SAW SHARPENING MACHINES

RUSSELL

S. RUSSELL & SONS LTD.
Bath Lane, Leicester

Backed by 45 years of specialised experience

SR 604

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or more particularly in *OUR SPRINGS* . . . . a high class range of coil and flat springs which cover "one off" or bulk production to your specification.

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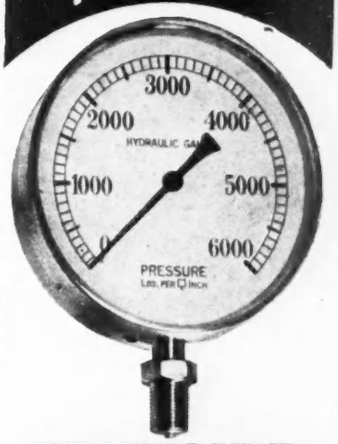
To gauge your requirements



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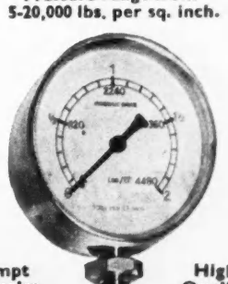
GAUGES

OF EVERY DESCRIPTION & SIZE

Pressure range from 5-20,000 lbs. per sq. inch.



Prompt Deliveries **Highest Quality**

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EAGLE & WRIGHTS (GAUGES) LTD.
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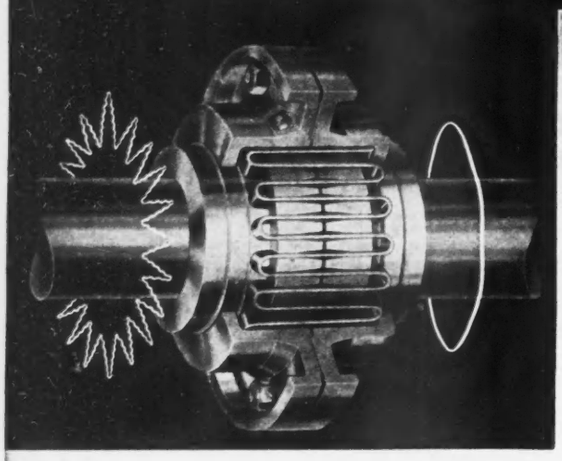
The most efficient couplings obtainable



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Resilient

COUPLINGS

For nearly forty years Bibby Resilient Couplings have enjoyed an unexcelled reputation for efficiency and reliability and numerous Couplings supplied over thirty years ago are still giving trouble-free service.

The outstanding resilience of Bibby Couplings dampens shocks and vibrations, ensures smooth running of plant, eliminates breakdowns. Standard Couplings up to 7½" bore can be supplied from stock.

We invite you to write for our illustrated brochure.

THE WELLMAN BIBBY COMPANY LIMITED
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1

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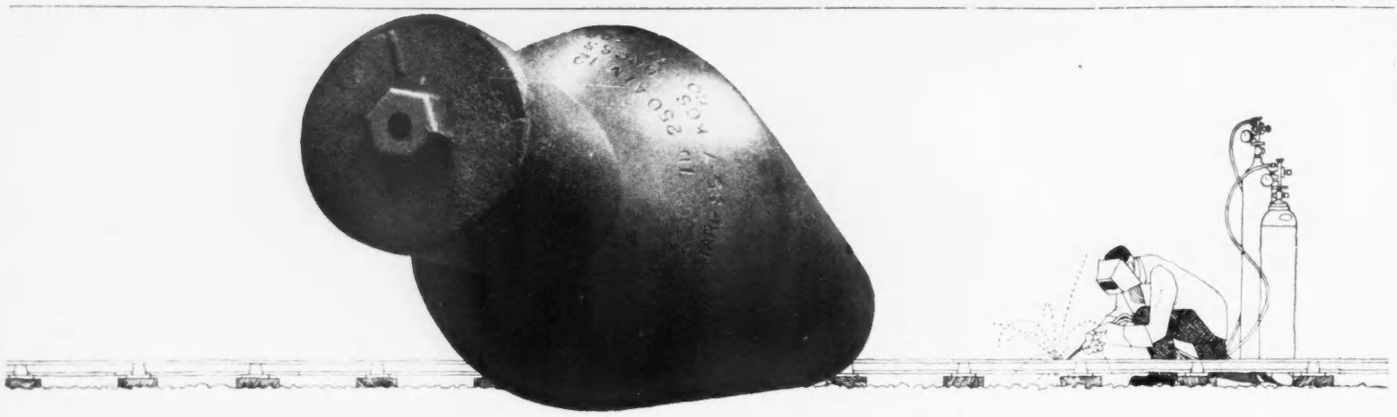

WHAT'S IN A TUBE?

At Chesterfield we can look back on over fifty years' experience in punching and drawing stubborn billets of steel into every shape and size of tube and hollow. This experience helps us to turn out impressive numbers of pressure vessels and gas bottles too. Whether you're on or off the beaten track, you are likely to come across the familiar shape* of a Chesterfield gas cylinder—one of over 9,000,000 already serving the needs of industry, medicine and construction the world over.

**Chesterfield gas cylinders are cold drawn, seamless and as perfect as our modern plant and manufacturing technique can make them. Chesterfield Cold Drawn Seamless Steel Gas Bottles are manufactured to conform to the specifications and regulations prescribed by the competent Authorities in all countries.*

chesterfield tubes

THE CHESTERFIELD TUBE COMPANY LIMITED CHESTERFIELD ENGLAND · A TI COMPANY

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GERMAN INDUSTRIES FAIR
HANNOVER
24 APRIL — 9 MAY 1960
FOR FURTHER PARTICULARS PLEASE APPLY TO
DEUTSCHE MESSE- UND AUSSTELLUNGS-AG.
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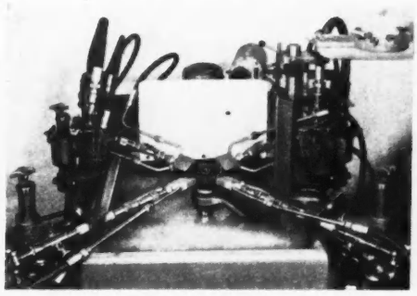
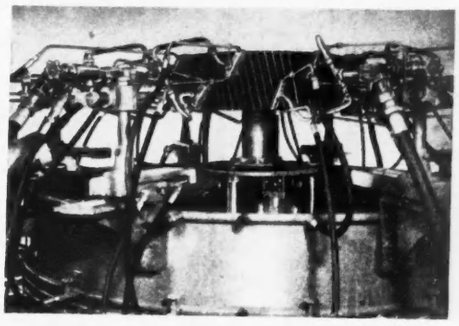
OXY-TOWN-GAS
SURFARD-PEDDINGHAUS
CONTROLLED FLAME HARDENING
Remarkable Development in
PRECISION GEAR HARDENING
LATEST SPIN-HARDENING PROCESS



Fully Automatic Plant rapidly produces identical results. Entire programme is pre-set and is continuously monitored by Milliscope Automatic Temperature Control.

This system is suitable for a wide range of components from small pinions to gears up to 60in. diam. and 10in. tooth width.

No over-heating of top of teeth.
Human element eliminated.
Extremely low cost.



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WIND ALARM ANEMOMETER

GIVES A **WARNING** OF WIND SPEEDS

FOR USE ON CRANES, TRANSPORTERS, DOCKSIDE STRUCTURES, BRIDGES & AIRPORTS.

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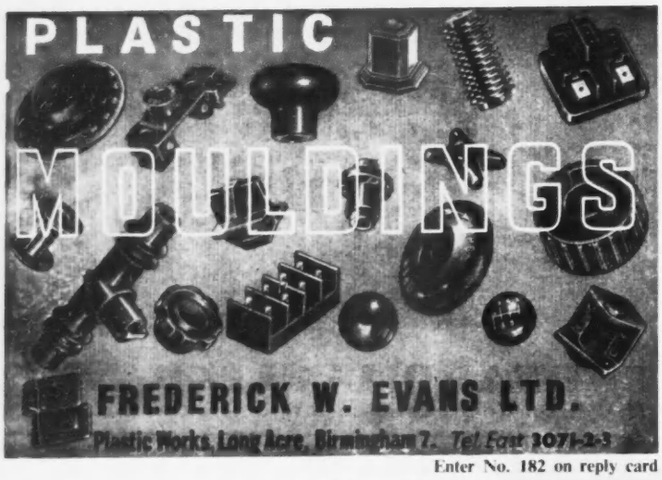

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for every conceivable purpose!

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–of course!

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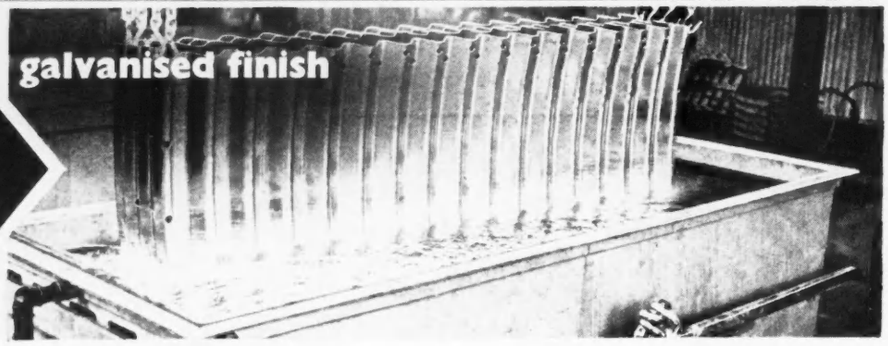
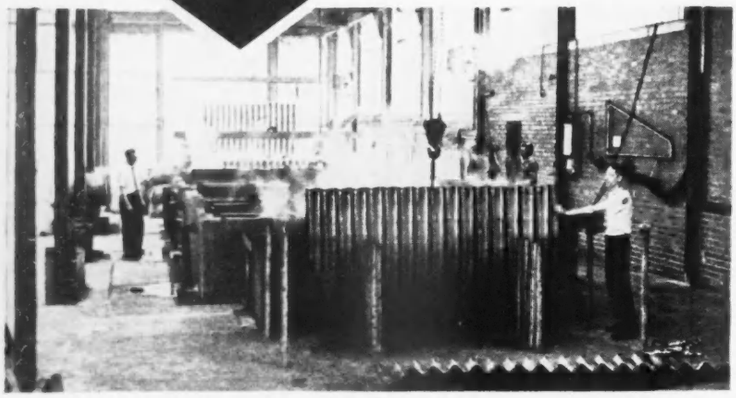
for the best galvanised finish



with the utmost economy in operation



automatically controlled hot dip

GALVANISING PLANTS

We can supply galvanising equipment to suit all requirements, from the specially designed bath to a complete plant with all auxiliaries. Our Radiant Wall design and close Temperature Control are features which ensure maximum fuel economy, elimination of dross from the coating, and give the finest finish at lowest cost.

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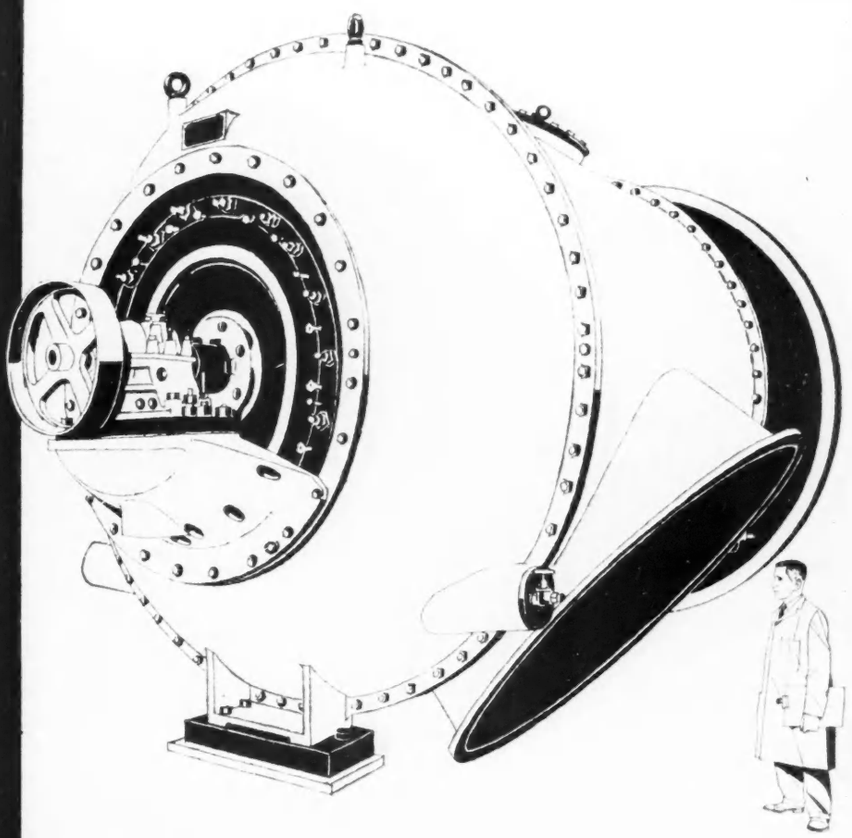

built by BROTHERHOOD

A Francis water turbine designed by Boving and Company Ltd.

Peter Brotherhood Ltd.
have the capacity, backed by skill
and experience, to
build prototypes, pilot plant and
full scale production
machines for new projects
or enterprises.

PETER BROTHERHOOD LTD

PETERBOROUGH ENGLAND

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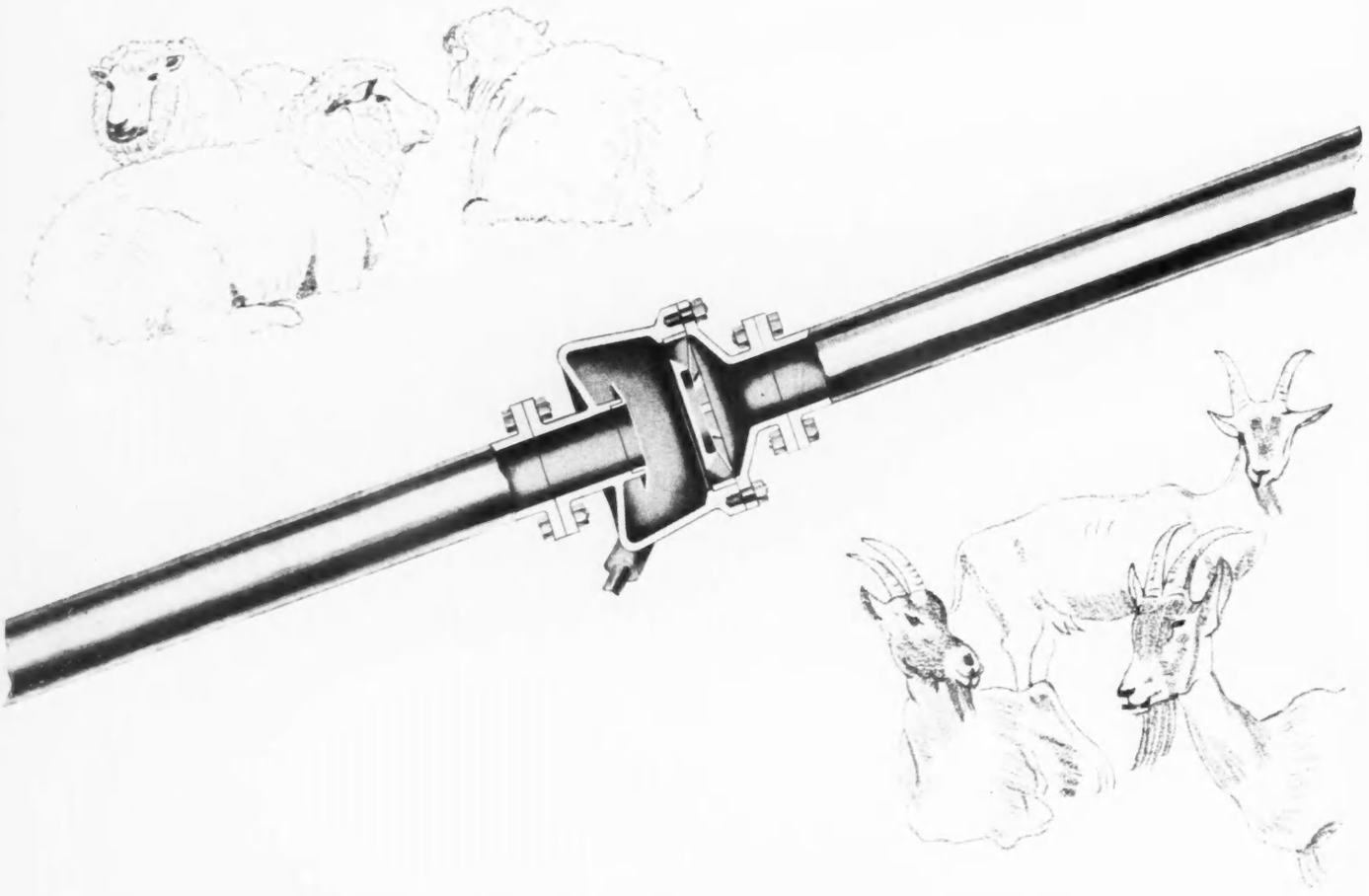
Sheep and goats!
Oil and Water!
it's all a matter of separation



We cannot deal with sheep or goats, but the 'Supreme Vortex' pipe line separator is unsurpassed for separating . . . .

Moisture **and oil drops from compressed air**
Moisture **from steam**
Dirt particles **from gases**

carruthers
SEPARATOR DIVISION

J. H. CARRUTHERS & CO. LTD., COLLEGE MILTON, EAST KILBRIDE, GLASGOW.
Telephone: East Kilbride 20591
Telegrams: 'Hoisting' East Kilbride
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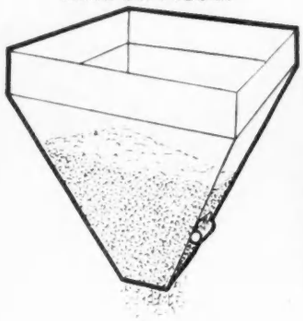
LESS-DIFFICULT



The installation of an external vibrator to a steel hopper.

trouble-free bunker discharge

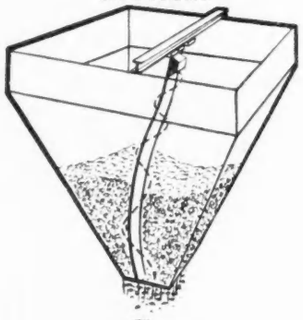
The primitive, inefficient method commonly used for clearing material which sticks in a storage bunker is by applying a sledge hammer to the side of the hopper. This is a form of low frequency, uncontrolled vibration. When vibration is applied at the *correct* frequency, the *correct* amplitude and the *correct* point of application, almost any material can be satisfactorily discharged.

SINEX has the experience with a wide variety of materials and a wide range of hopper designs to recommend how vibration should be applied effectively to solve *your* particular problem.

The three examples illustrated show three different combinations which are typical of many applications, but even these, whilst using the same type of unit, can only be effective if the types of unit themselves are placed in the correct position and have the correct frequencies and amplitudes of vibration to suit the characteristics of the material to be discharged.

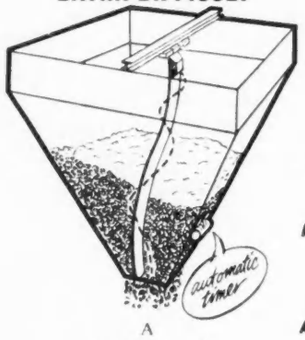
It would pay you, therefore, to make use of our experience and to consult us on your particular problem. Send for relevant details and information sheet.

DIFFICULT



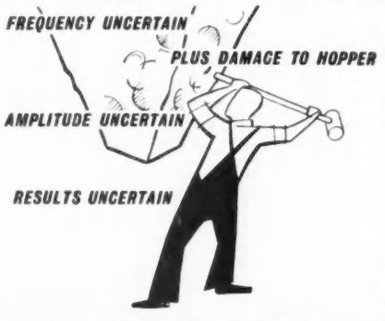
The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

EXTRA-DIFFICULT



A combination of internal and external bunker vibration. Where the external vibrator is timed for 'on and off', the vibration frequency, on slowing down, goes through the natural resonance of the bunker, irrespective of load material contained.

ELIMINATE THIS WASTEFUL METHOD



These are some of the many materials which we have handled satisfactorily and ensure trouble-free bunker discharge : Pulverized and small coal, iron-ore, coke, lime, flour, grain, grist, foundry sand, soda ash, cullet, sand, gravel, granite chips and all road stone materials.

Sinex

Bunker clearance Equipment

SINEX ENGINEERING COMPANY LIMITED.

Central Way, North Feltham Trading Estate, Feltham, Middx.

Tel : Feltham 5081 (5 *lines*) *Telegrams : Sinexvibro Feltham.*

ASSOCIATED COMPANIES IN PARIS, BRUSSELS AND ZURICH

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The RIGHT pressure ALL the time...

Norgren

PRESSURE REGULATORS

For any kind of air-operated equipment, there is one pressure at which it is designed to operate most efficiently. At a higher pressure the equipment will wear excessively — with no significant increase in output — and compressed air will be wasted. A Norgren Pressure Regulator ensures that each tool, valve or cylinder receives the exact pressure at which it operates most efficiently and maintains that pressure even though the line pressure may fluctuate. SAVE maintenance costs, CUT compressed air wastage and IMPROVE performance. Write now for full details.

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COMPRESSED AIR FILTERS REGULATORS, LUBRICATORS

C. A. NORGREN LTD., SHIPSTON-ON-STOUR, WARWICKSHIRE *Tel : Shipston-on-Stour 110 & 106*

COMPRESSED AIR NEEDS *Norgren* EQUIPMENT

M-W.136

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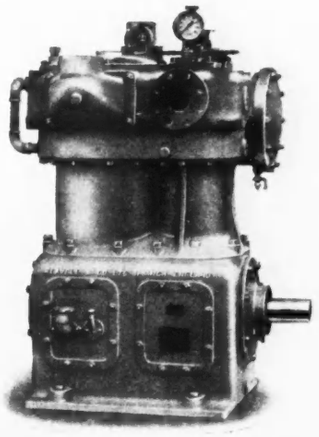
AIR COMPRESSORS

VERTICAL SINGLE-ACTING TYPE

SINGLE STAGE.	100 LB. PER SQ. IN.	1 TO 155 CU. FT. PER MIN.
	60 LB. PER SQ. IN.	1 TO 380 CU. FT. PER MIN.
TWO STAGE.	100 LB. PER SQ. IN.	200 TO 310 CU. FT. PER MIN.



FOR PARTICULARS OF THESE COMPRESSORS AND FOR OTHER TYPES AND SIZES
TELEPHONE : IPSWICH 56124 (3 LINES)
TELEGRAPH : "REAVELL, IPSWICH" OR WRITE TO :—

REAVELL & CO., LTD.
IPSWICH - ENGLAND

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PAT. NO. 507249

THE GENERAL PURPOSE FASTENER FOR ENGINEERS.

Simple — Positive — Self-Locking. Made in a variety of types and sizes. Special Fasteners to suit customers' requirements.

Used on aircraft, automobiles, coaches, caravans, rail coaches, electrical, radio and radar units, refrigerators, marine craft, display equipment, etc.

For quickly detachable doors, covers, panels, access covers, etc.

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CRANE BLOCKS
SINGLE AND MULTIPLE SHEAVE
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FOR WIRE ROPE

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These benches can be supplied with sheet steel top. Overall size of bench 6' 0" long by 2' 6" wide by 33" high.

BENCH TRESTLES

STOCK SIZE 28½" wide by 32" high. Other sizes manufactured to suit customer's requirements.

If you've a storage problem— FASE can help you solve it. There is a wide range of FASE unit-construction Steel Storage Racks and Equipment including :

★ **WORKSHOP PANS & PAN RACKS**
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AND MANY OTHER TYPES OF STORAGE EQUIPMENT

IF IT'S IN STEEL WE MAKE IT!
Send us your requirement

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TILLEY
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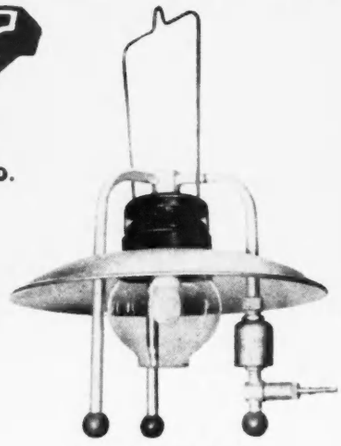
PROPANE . . . *versatility* . . . BUTANE



B.T.27 Shaft or Manhole light.

lighting — heating

B.T.25 FLOODLIGHT 10,000 M.R.C.P.

B.T.25 complete with Fog Filter 1712.

B.T.25 complete with Guard 1623.

B.T.25 complete with Frosted Glass 1624.

We don't often blow our own trumpet. We would like to give a blast or two to introduce you to our range of lamps and heaters all operating on Propane/Butane. They are quite exceptional—but then they are designed in co-operation with the men on the job!

CONSULT US FOR LIGHTING AND HEATING!

We can only illustrate three from the range of these versatile lamps and heaters. We suggest you investigate. It's well worth while!

Please write for illustrated leaflets to Dept. EN.12

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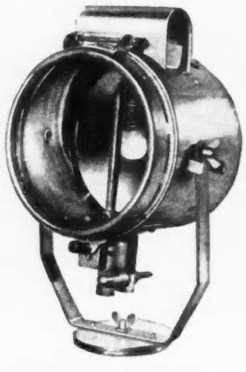
LAMP COMPANY LIMITED
70-72 JERMYN STREET, LONDON, S.W.1



B.T.44 Mounted on its stand No. 841

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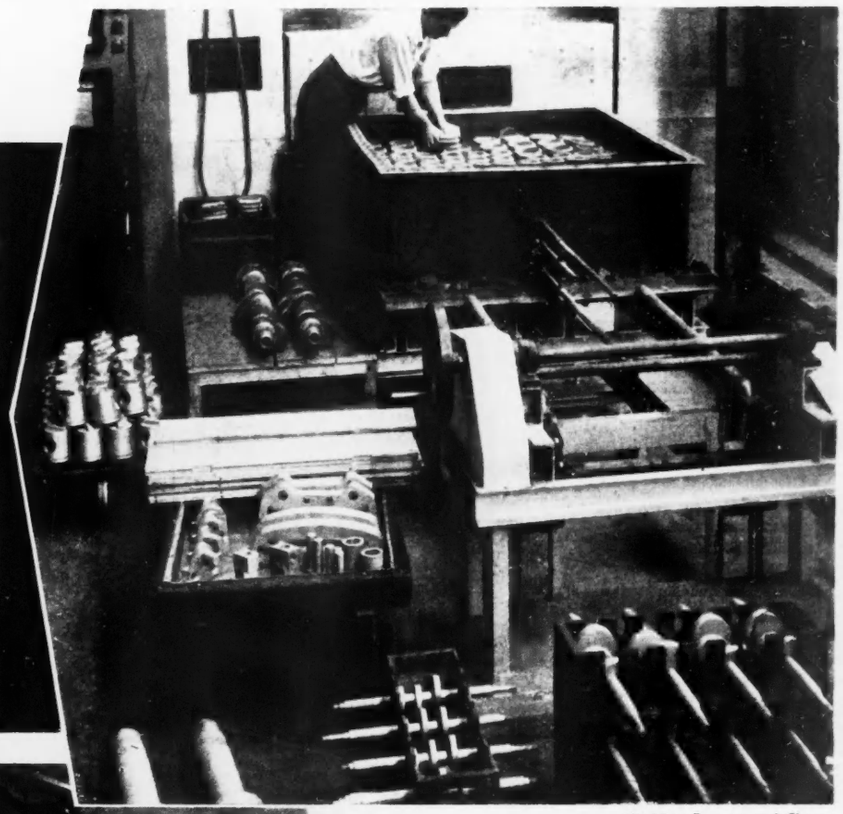
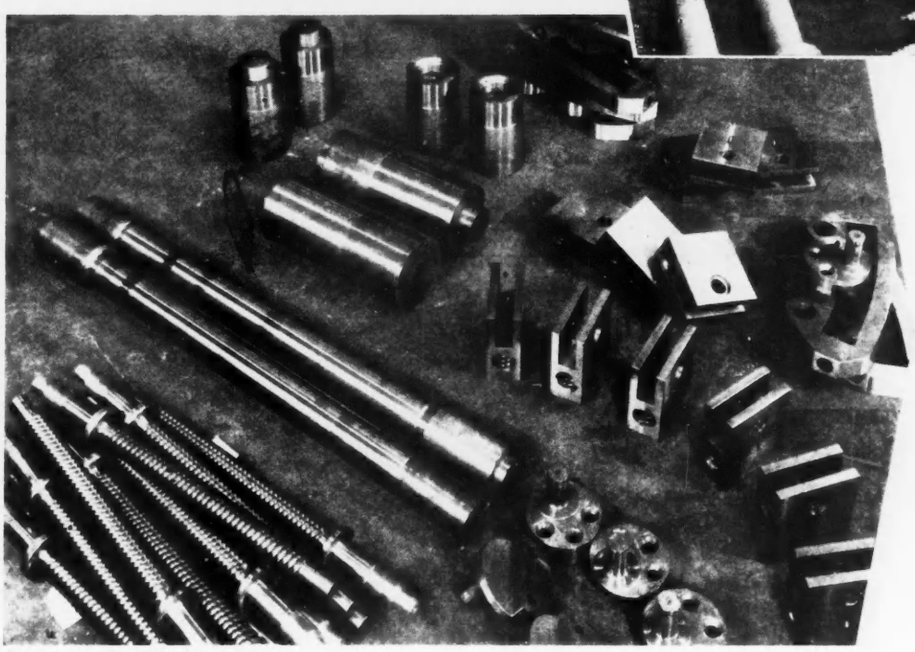
Nitriding Steels

for all wear resisting applications



Nitriding Furnace and Charge



Typical examples of Nitrided Products

These special steels have become firmly established as the most suitable for engineering purposes where maximum resistance to abrasion is required.

Nitriding steels offer the following advantages:—

- The best degree of surface hardness for a particular job.
- Minimum distortion during nitriding.
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ALLOY STEELMAKERS • FORGEMASTERS • STEEL FOUNDERS • HEAVY ENGINEERS

THOS. FIRTH & JOHN BROWN LIMITED • SHEFFIELD • ENGLAND

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DOUBLE BOND
HERMETAL

epoxy
STRUCTURAL PLASTIC

DISCOVER NEW WAYS
of cutting time and cost in making parts and components and for many types of repairs. DOUBLE BOND—an entirely new material—can be used for jointing, filling and moulding, or fabrication of actual parts. This versatile self-setting structural plastic is available in two grades; one moulds like putty for filling in depth, the other spreads like cream for shallower and larger areas. Both set like lead, machine like brass and can be used as a cold solder. Write for 7/6d. trial pack which includes both grades.

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THE KENILWORTH MANUFACTURING CO. LTD., WEST DRAYTON, MIDDLESEX

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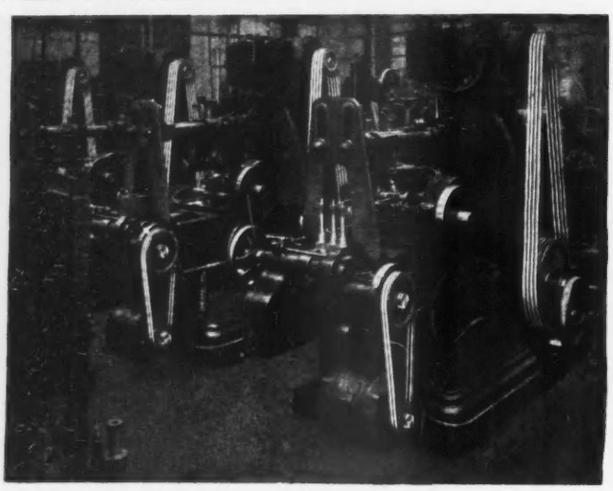
a century of experience in
V-ROPE DRIVES



Thrapston V-Rope Drives are designed to give maximum efficiency, long life and flexibility, producing trouble-free smooth, silent, clean running.

SMITH & GRACE Ltd.
THRAPSTON, NEAR KETTERING

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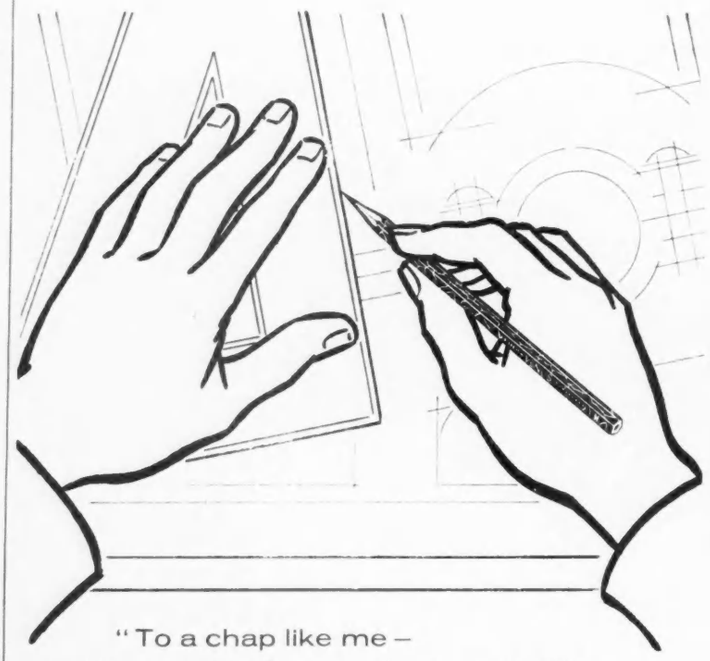

"To a chap like me –
and I'm proud of my work – my pencil's
my living.
The pencils I use have to stand up to fast
hard work, their grading's got to
be absolutely spot on – not almost
or nearly but bang on the dot every
time.
The leads must hold their points
and flow smoothly throughout a long line –
no crumbling or 'clinkers' mark you! –
and if I erase a line it must go cleanly –
there's no 'furrow' left in my paper
so you won't find ghost lines in prints
made off my drawings. As a matter of
fact you can tell from a print when it is
my drawing – the print's always first class."

"What pencils **do** I use?"

"Venus drawing pencils of course, the ones
with the crackle finish! – how else
do you think I keep up my high standard?"

VENUS
DRAWING
PENCILS

★VENUS *Drawing Pencils are made in* 17 *accurate grades from* 9*H to* 6*B.*

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GUEST KEEN IRON & STEEL COMPANY

- **STEEL** BLOOMS · BILLETS SLABS · SECTIONS COLLIERY ARCHES · PIT PROPS ROOFING BARS · LIGHT RAILS SLEEPERS and HAMMERLOCK STRUTS
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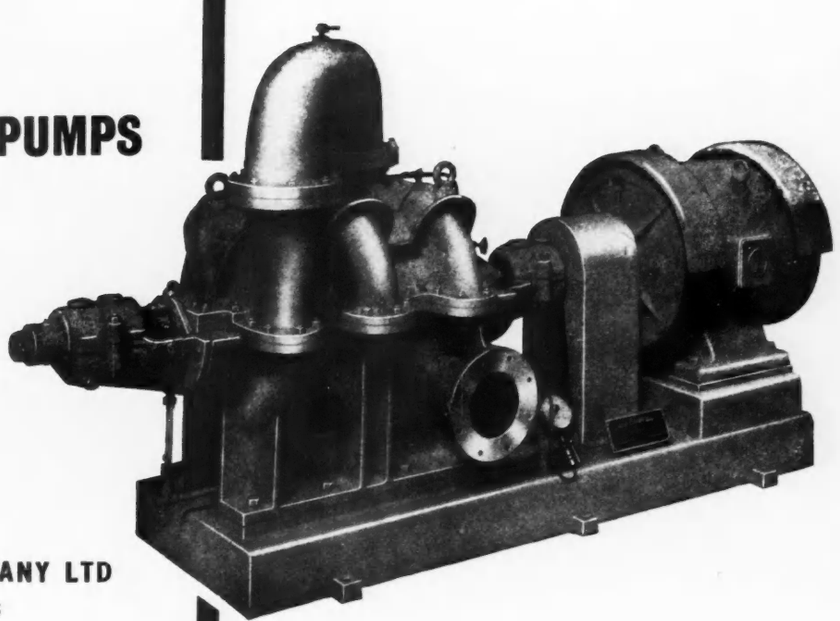
Mirrlees'

CONDENSATE PUMPS



Three Stage Condensate Extraction Pump.

THE MIRRLEES WATSON COMPANY LTD

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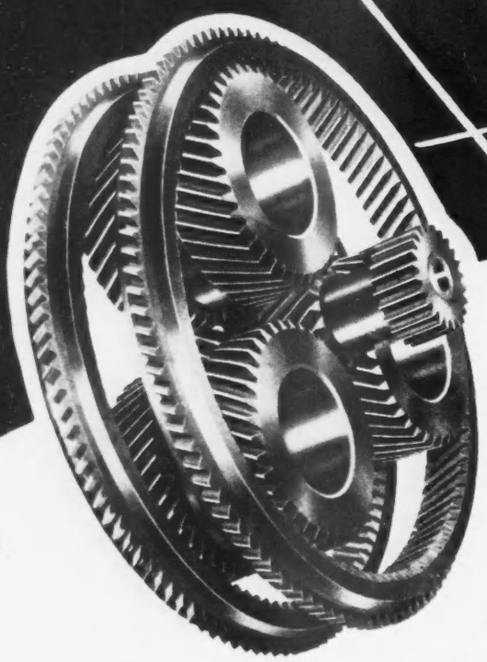

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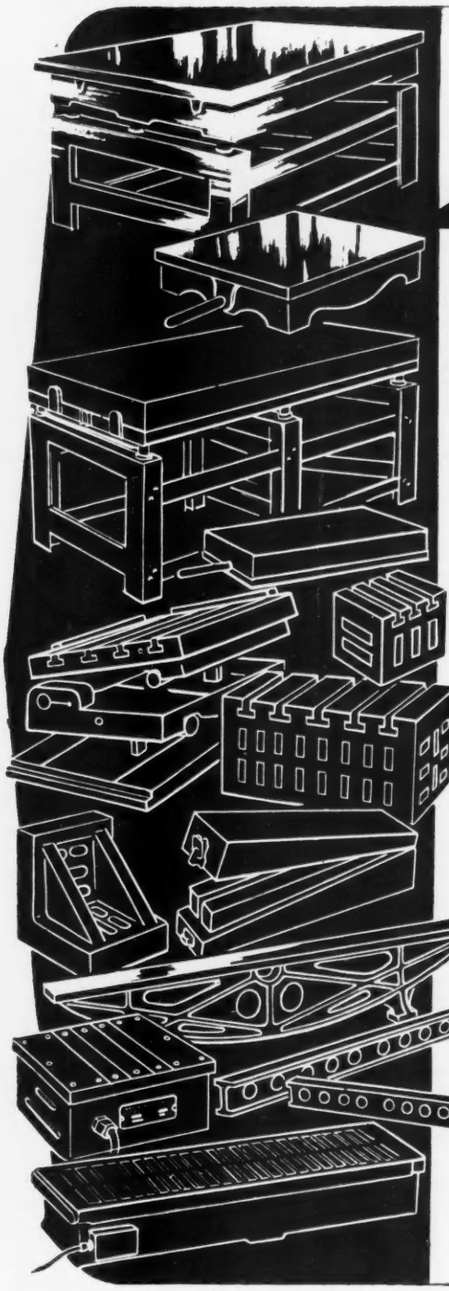

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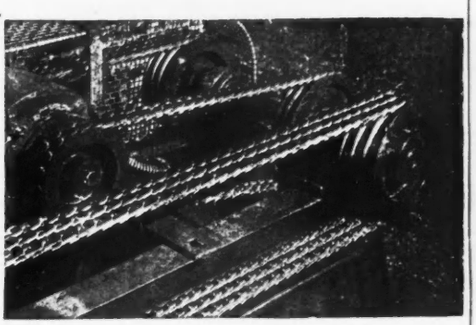

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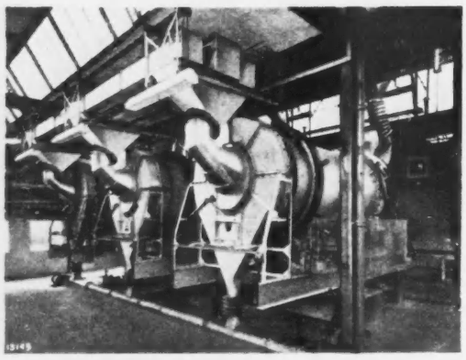

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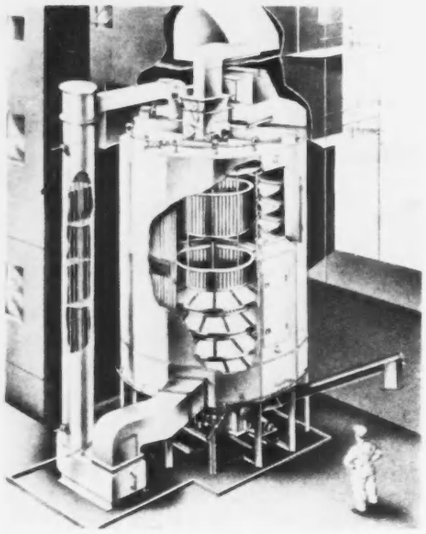

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Cutaway illustration of a typical Sturtevant Wyssmont Vertical Turbo-Dryer

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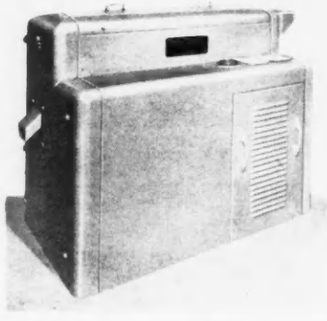

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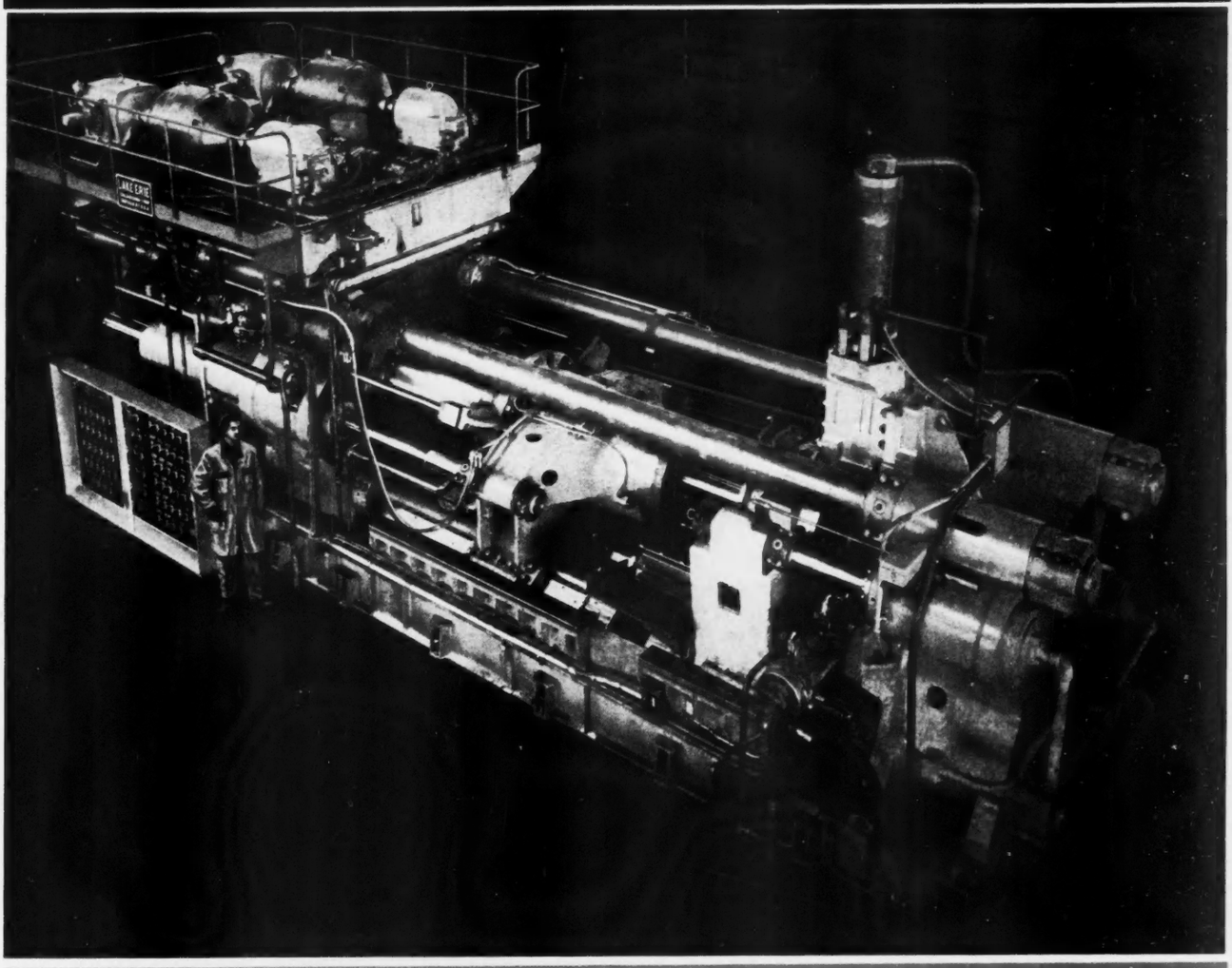

The above illustration shows a 3000-ton Lake Erie Extrusion Press for non-ferrous metal tubes and rods with direct oil-hydraulic drive

The combination of the production programme of **LINDEMANN** *Press Builders,* **DUSSELDORF,** *and of* **LAKE ERIE MACHINERY CORPORATION, BUFFALO 17, N.Y., USA,** *supplementing each other and the exchange of technical experience will increase the capacity of both companies to the profit of their world-wide clientele.*

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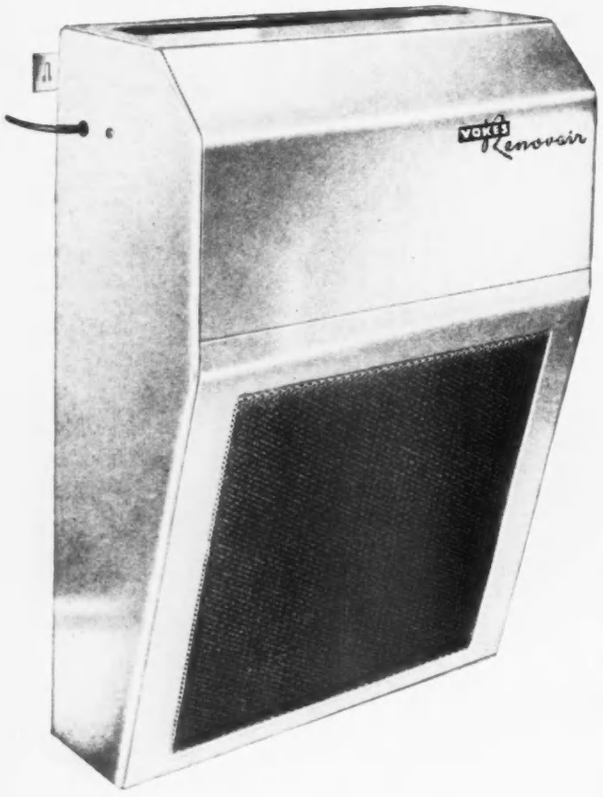

Vokes' new Renovair is ideal for use in meeting halls, offices, restaurants or any building or room where people congregate. Simply switch it on and it immediately reduces the amount of tobacco smoke in the atmosphere, clearing it completely within a few minutes. Besides the obvious advantages to health, improved visibility and cleanliness, the use of a Renovair leads to enormous savings on the upkeep and renewal of furnishings and paintwork. In addition, because it *cleans* the air and re-circulates it, heat loss is eliminated and heating bills are considerably reduced.

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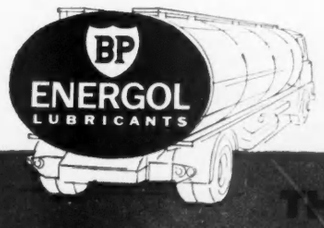

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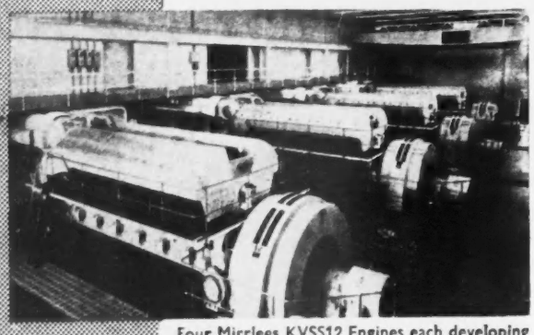

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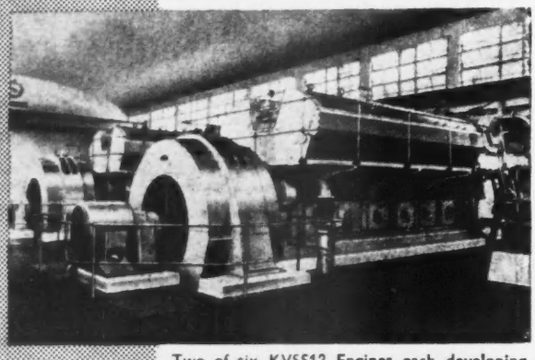

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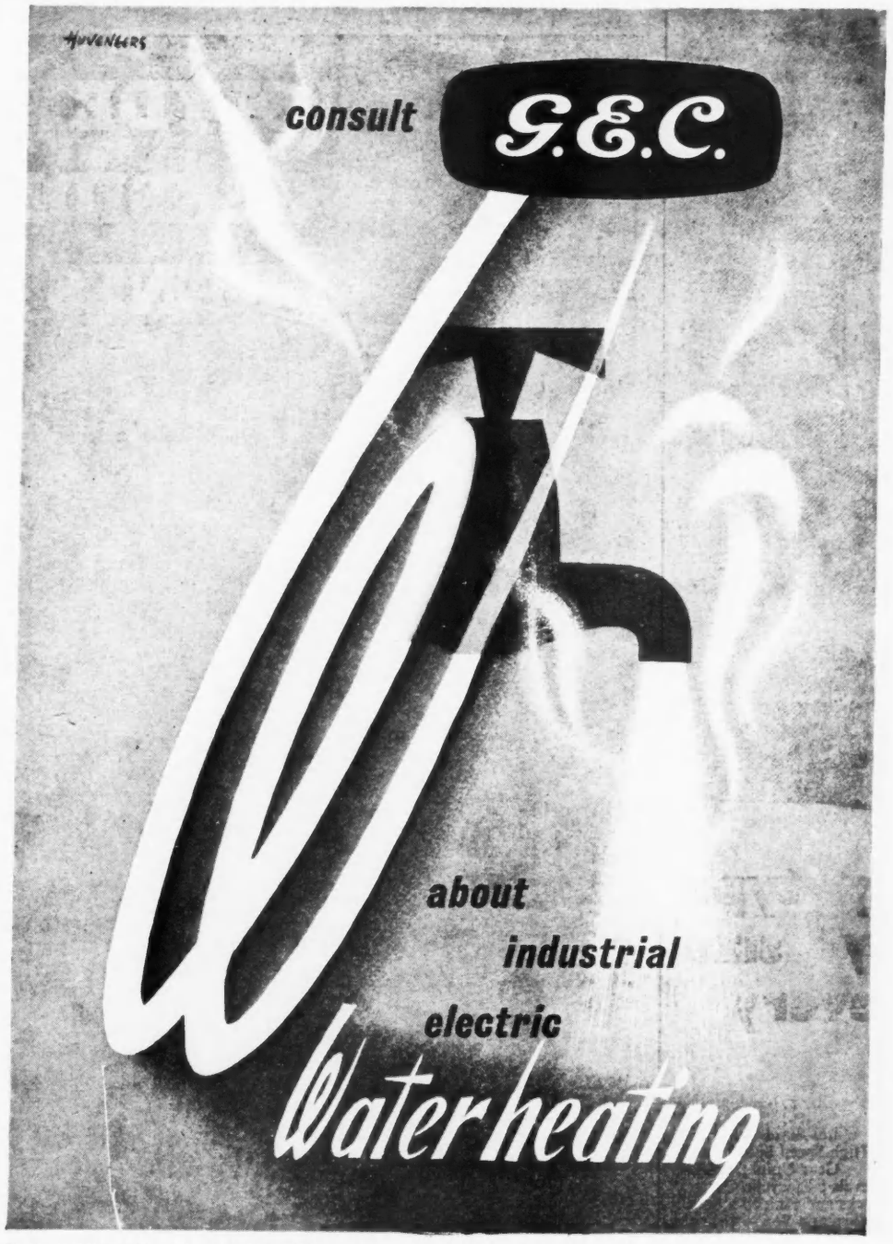

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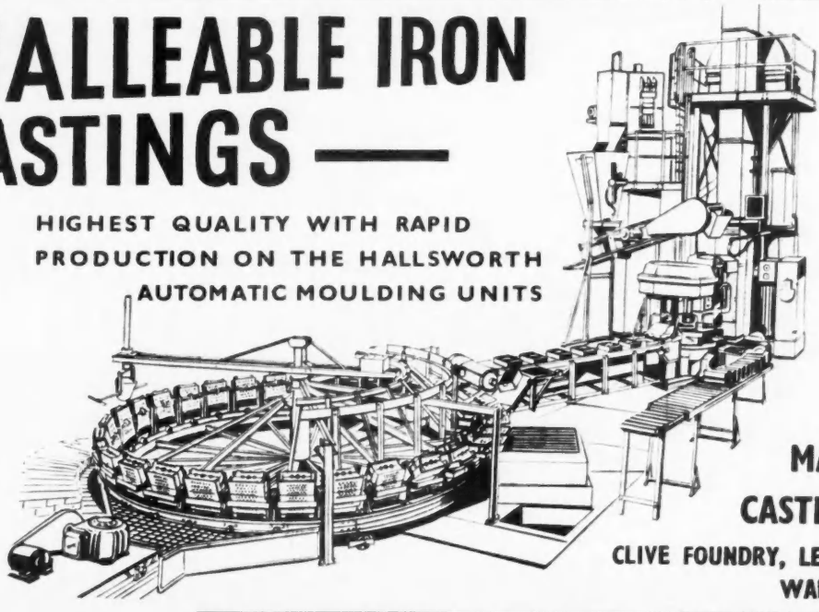

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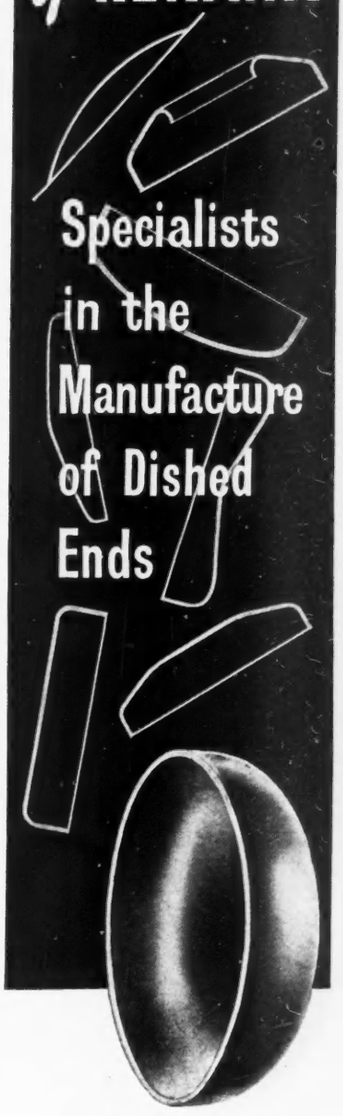

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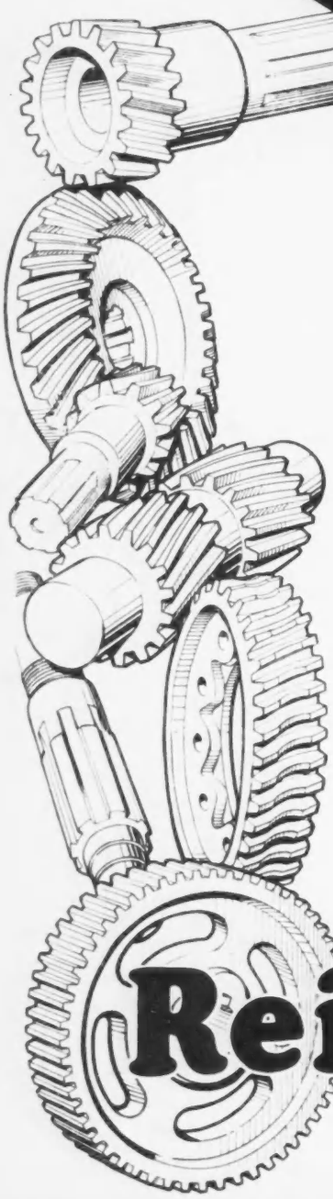

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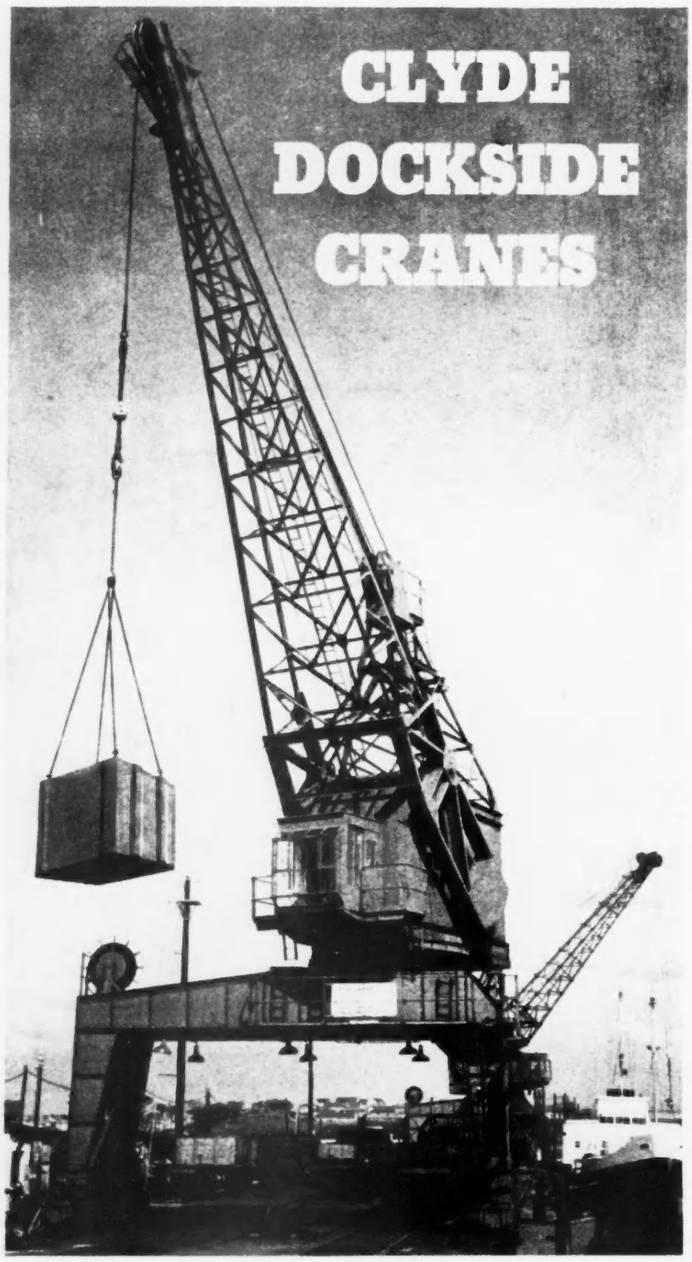

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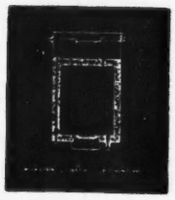

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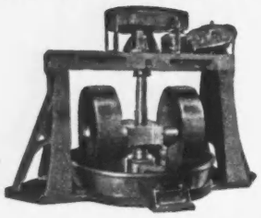

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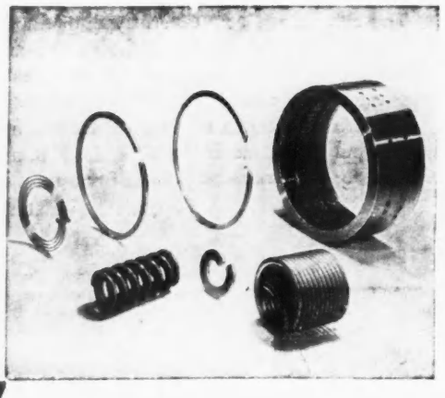

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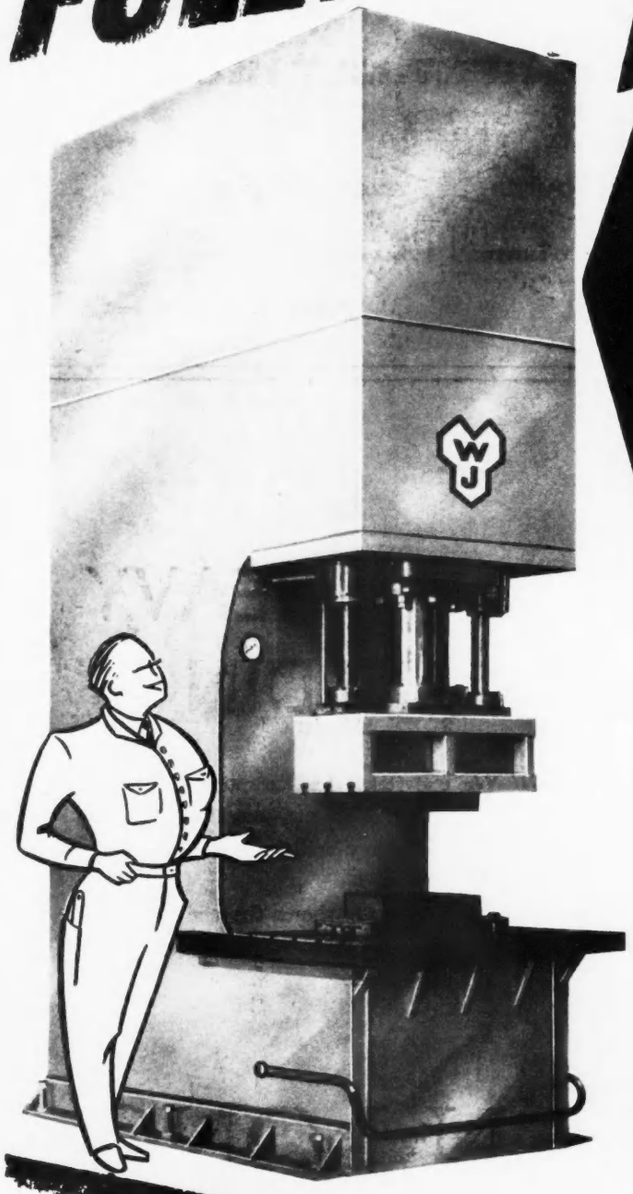

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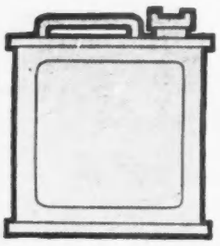

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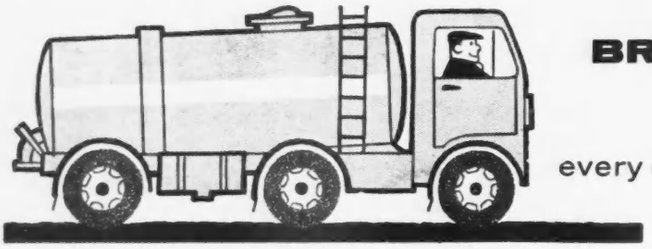

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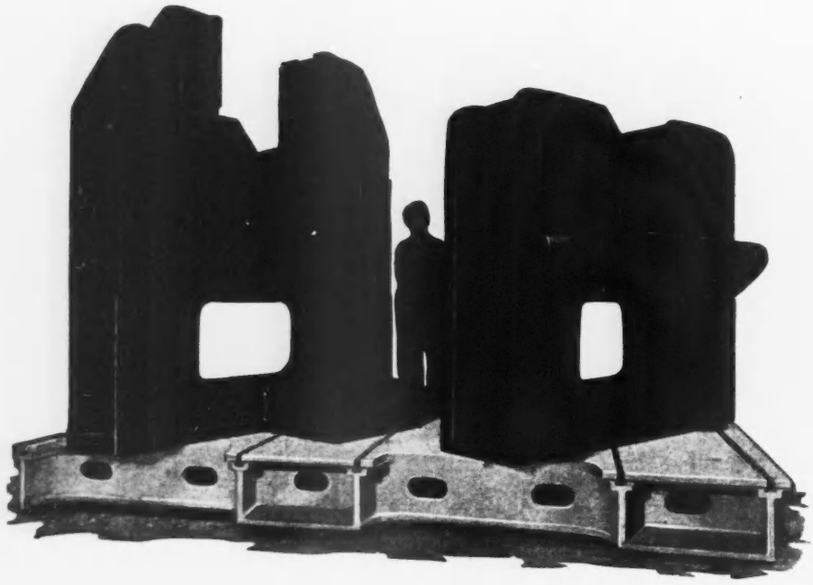

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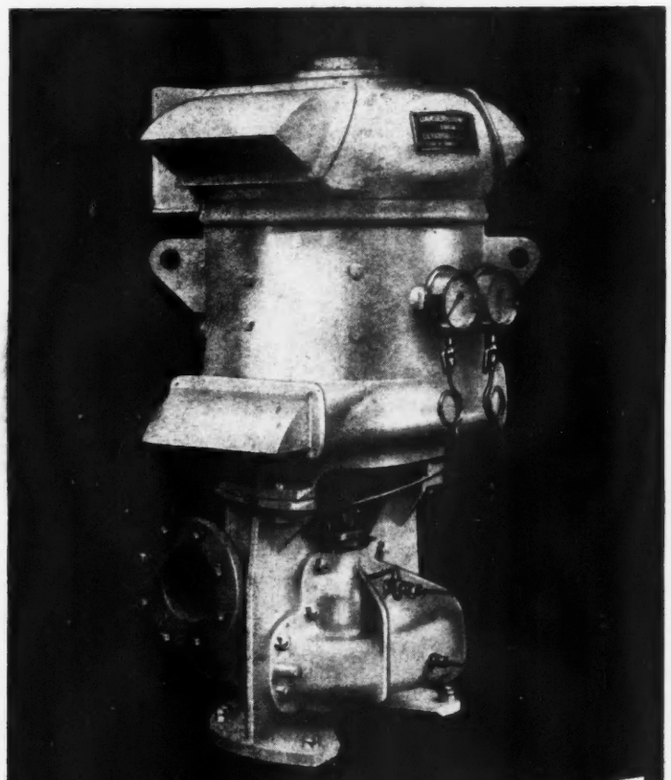

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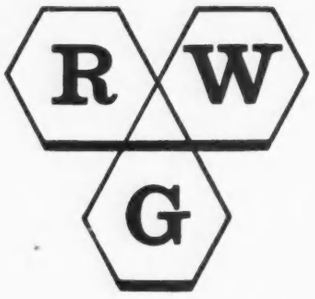

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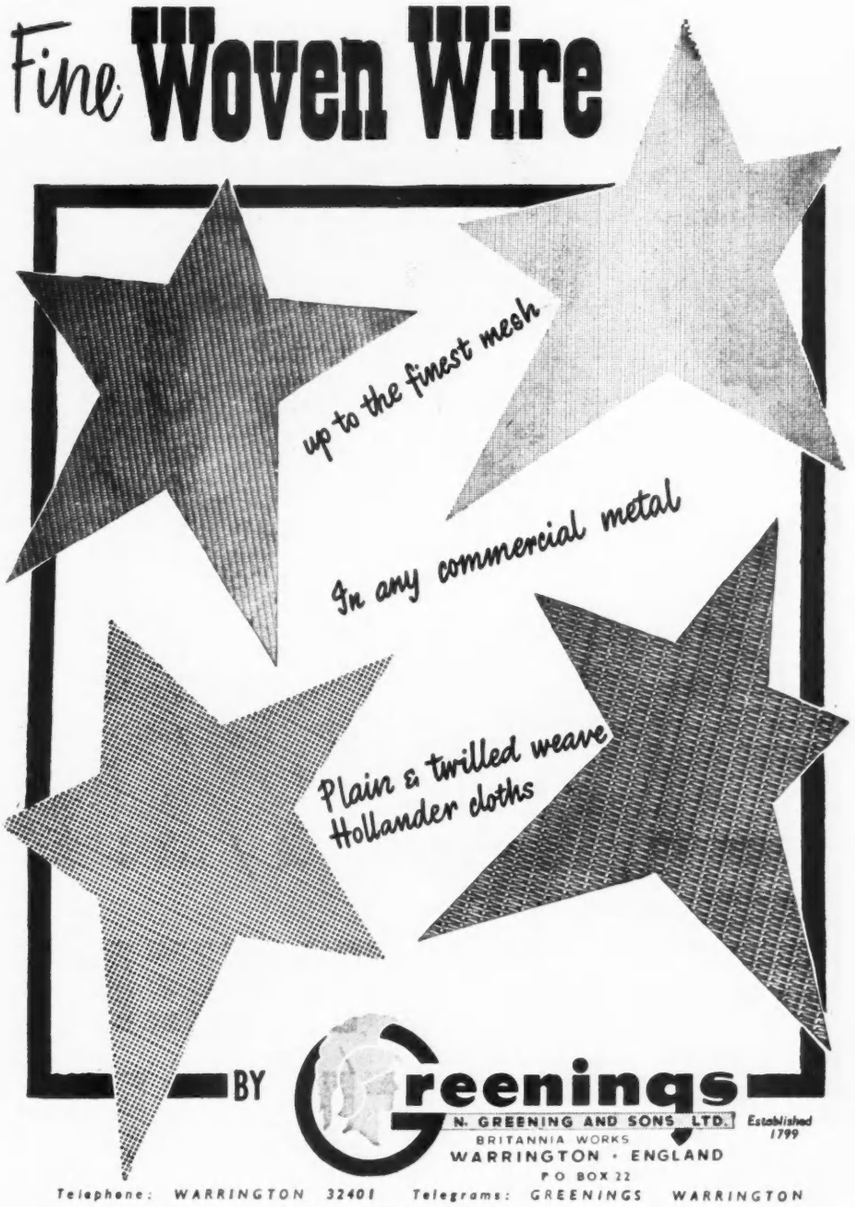

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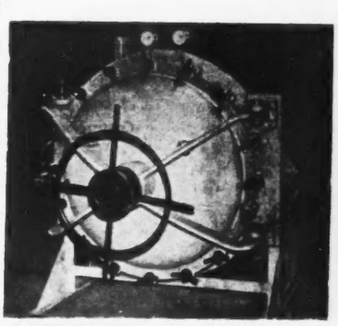

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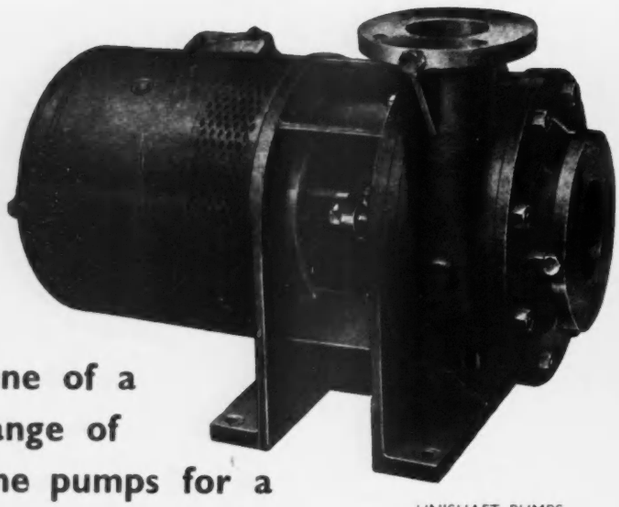

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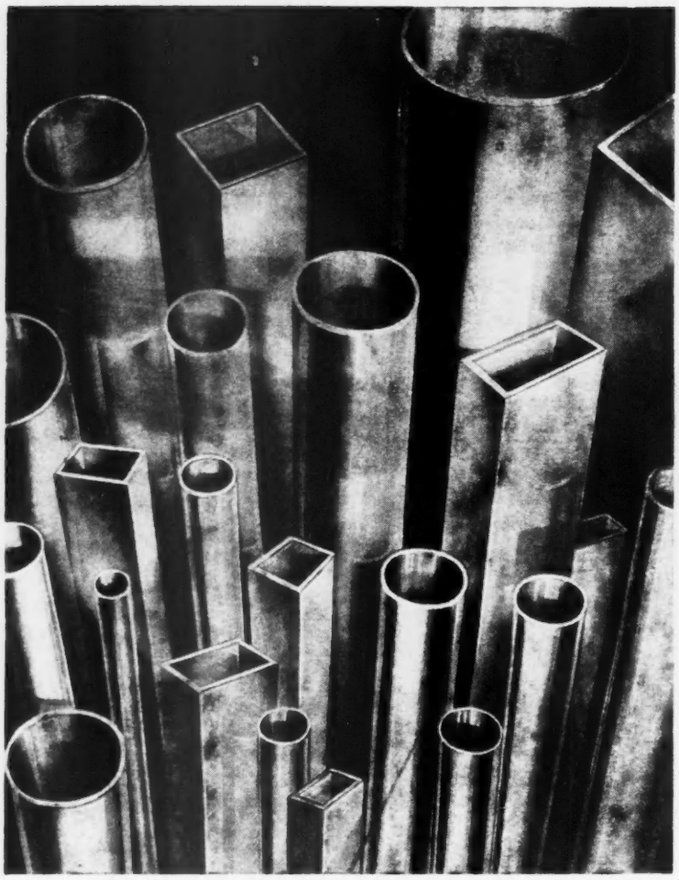

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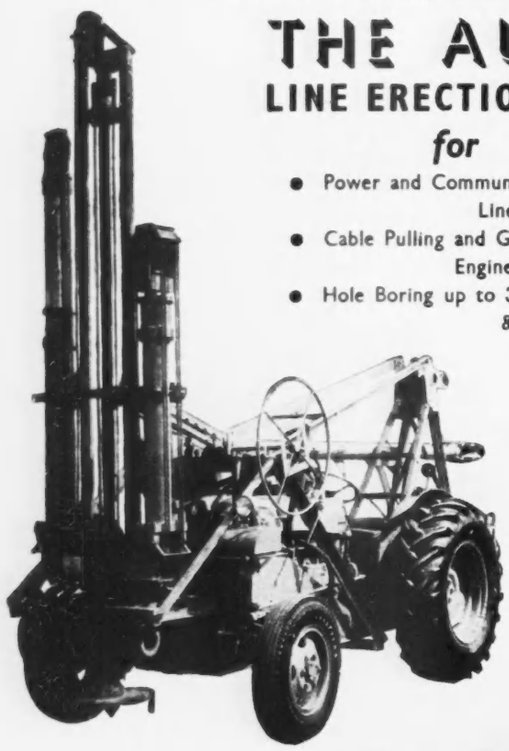

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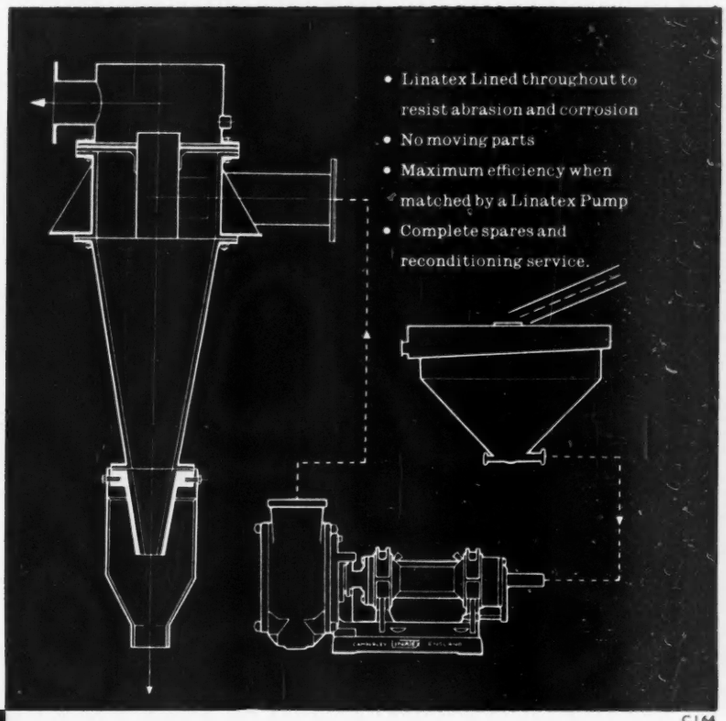
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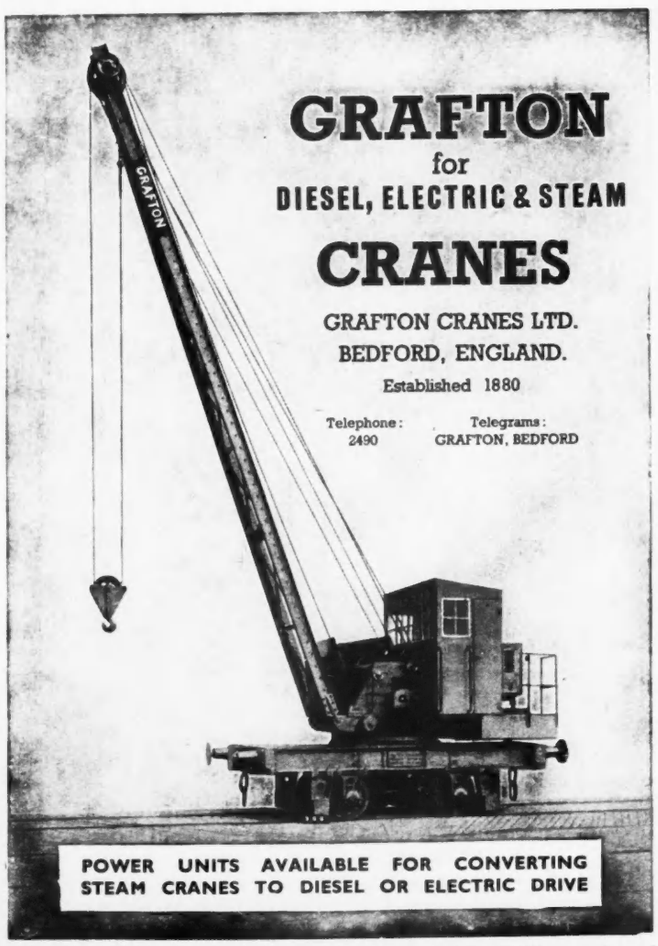

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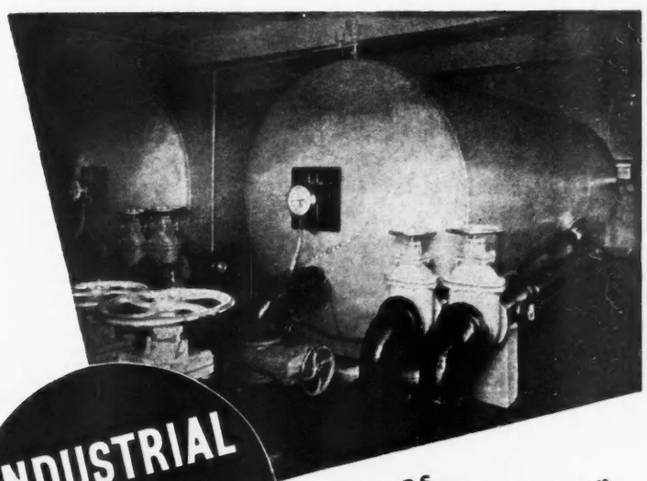

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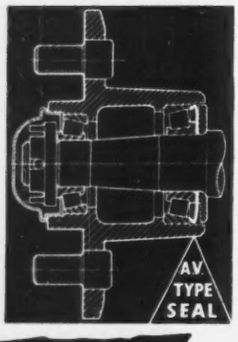

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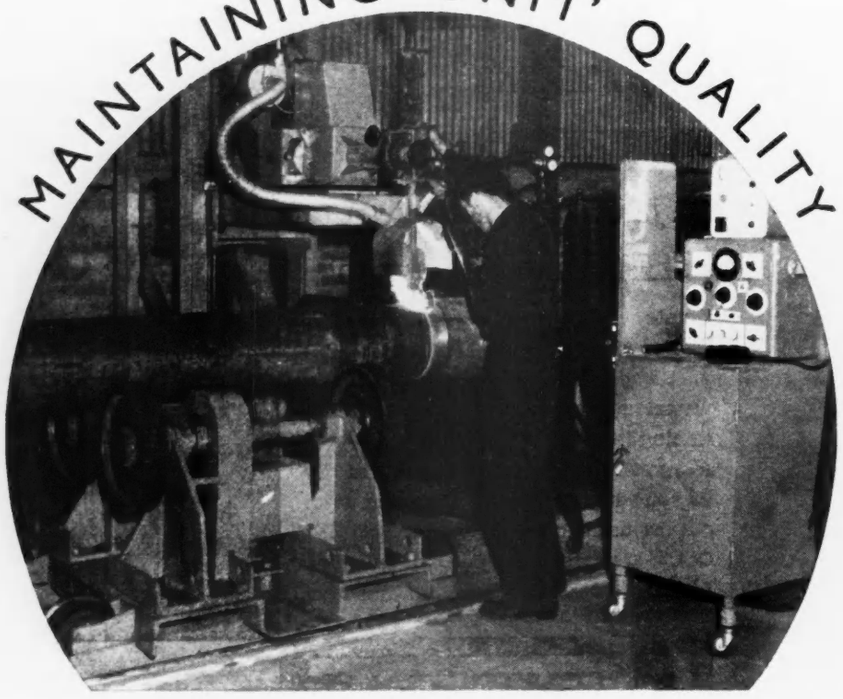

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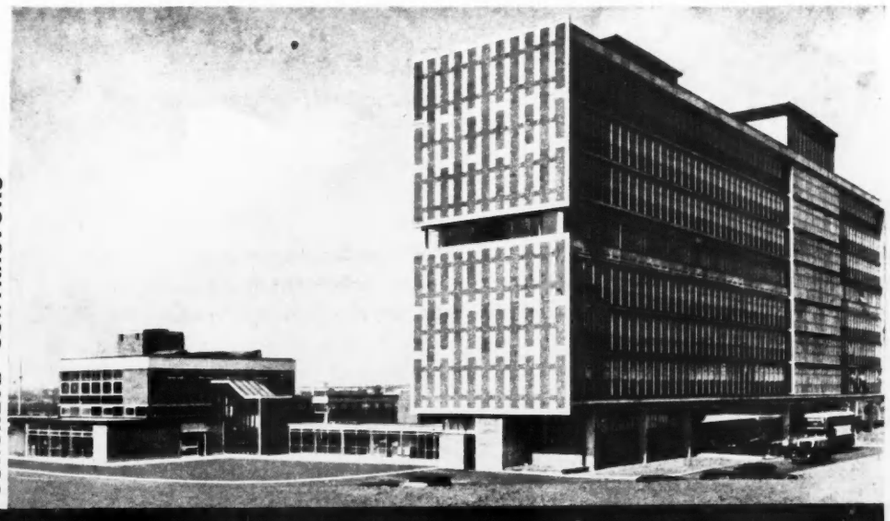

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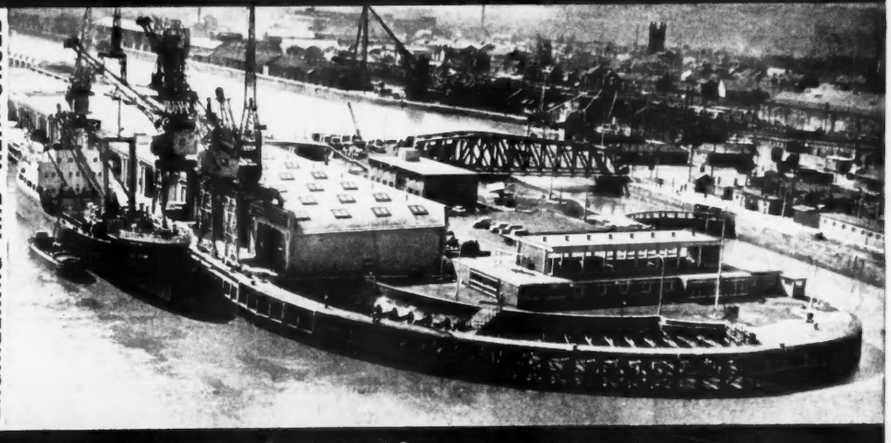

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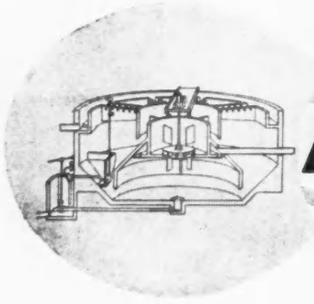

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THE ENGINEER

No. 5438 APRIL 15, 1960 VOL. 209

AN AIRCRAFT WEEK

Last week might almost have been termed aircraft week, so many things of interest to the aircraft industry occurred in those seven days. A Memorandum on "The Future of British Air Transport" was issued by the Air League of the British Empire; the Minister for Aviation announced substantial reductions of certain air fares, and the making of certain agreements between the British Overseas Airways Corporation and British European Airways on the one hand and a number of independent operators on the other to share certain economy services; it was announced that the Short SC-1 V.T.O.L. aircraft had successfully taken off vertically and gained flying speed in level flight and also completed the opposite manœuvre; if the "Hovercraft" can really be regarded as an aircraft it was interesting to hear during the week that the existing unit is to be fitted with an engine additional to the one that at present provides forward propulsion as well as lift, so that information can be gained about the behaviour of the craft when moving at higher speeds than at present; and, lastly, Mr. Cockerell in presenting a paper before the Royal Society of Arts discussed the possibilities of the "Hovercraft" for cross-Channel purposes.

It will be remembered that last autumn the International Air Transport Association meeting at Honolulu failed to reach agreement about air fares except those within Europe, between Europe and South America, and between North and South America, largely because the B.O.A.C. desired to lower them. Our Minister of Aviation thereupon decided in principle to authorise B.O.A.C. to reduce its fares on cabotage routes to the West Indies, Africa, and the Far East. As a consequence of that decision the I.A.T.A. reconvened its conference, and agreement was reached to make general reductions of about 16 per cent below the existing tourist class fares in a new economy class. Similar fares have now been approved by the Minister for British cabotage routes. However, the Minister has also decided, as he announced last week, to authorise certain new classes of fares at substantially still lower rates as much as 50 per cent below present tourist fares for certain routes. The decision to permit the Corporations to charge such low fares has impelled the Minister also to take action about the services which have been built up by the independent airlines; and as a result agreements have been reached between B.O.A.C. and British United Airways and between the same Corporation and the Eagle Airline and between B.E.A. and British United Airlines and between that Corporation and Skyways to operate certain services jointly. This lowering of air fares is welcome in several ways, first because people have become so used to prices rising in an inflationary economy that it is salutary to see that some can come down, secondly, because it is pleasing to see a commercial concern confidently reducing prices in the belief that any potential loss of profit therefrom will be compensated by a large increase in sales, and lastly because of the probability that British aircraft specially designed for short hauls at low costs may be benefited thereby.

The Memorandum of the Air League covers more controversial ground. For it relates to the future of Government aid for the aircraft industry. It is contended that if Britain is to maintain a place of importance in the design and production of aircraft it is essential to begin now the development of some future type of craft which will be in advance of any competitor by the time it comes into full production. What that type of aircraft should be is studied and the conclusion is reached that it should be a supersonic airliner capable of a speed of Mach 3. If that were all, the League's conclusions could hardly be regarded as satisfactory as the Americans are known to be some distance advanced already in overcoming the variety of problems which need to be tackled in the design of such a craft. The distinctive idea in the League's proposal is that the craft shall be capable of vertical take-off and landing as well as supersonic speed. Concurrently it is suggested that a similar, but sub-sonic, aircraft should be developed for short and medium stage operation capable of utilising landing "pads" close to the centres of cities. In the meanwhile the League feels that a use of the Fairey "Rotodyne" and helicopters should be encouraged, since extensive use of them would provide an opportunity to study what kind of organisation and air control system would yield the maximum benefit from vertical take-off and landing. Those recommendations take on an added interest in the light of the success of the Short SC-1 V.T.O.L. aircraft in maintaining stability while gaining flying speed.

It is, of course, doubtful whether the "Hovercraft" ought to be mentioned in the context of aircraft for although it is undoubtedly airborne it remains nevertheless earthbound! Yet the further development of the principle might have aircraft applications in that future aircraft may be able to dispense with conventional landing gear by riding on an air cushion. All this activity is not only intensely interesting in itself to aircraft enthusiasts but of substantial importance to engineers. For about one thing we think there can be little doubt. It is only because aeronautics makes such extreme demands upon engineering materials and upon the ingenuity and intuition and understanding of designers and manufacturers, leading thereby to advances in knowledge and techniques which can be utilised in other fields, that the heavy costs of the development of new aircraft to the National exchequer can be justified.

ROAD ACCIDENTS

The Ministry of Transport's monthly statistics of road accidents seem to be showing steady and disturbing increases in the number of casualties. February's figures show a 33 per cent increase of all casualties, over February, 1959. The number of people killed on the roads during the month was 458 and the total number of casualties of all kinds was 5085. According to the Road Research

Laboratory, traffic was 16 per cent heavier in February, 1960, than in February, 1959. The figures show that casualties among drivers of "mopeds" increased by 85 per cent, and among drivers and passengers of motor-scooters by 90 per cent; the estimated corresponding increases in vehicle mileages being 28 and 61 per cent. It is astonishing that such high rates of casualties continue to be accepted with apparent equanimity by the vast mass of public opinion. Some progress has undoubtedly been made in combating road accidents, as a study of the statistics over the years show. For instance, road deaths have generally fluctuated around 6000 a year for over thirty years, without substantial change, if the war years are excepted; the greatest increases were in the 'thirties, and some reduction has been achieved since then, even though motor traffic has increased enormously. Total casualties have increased fairly steadily over this period, but at less than half the rate of fuel consumption. Yet the total figures are so large as to defeat any sense of achievement in such "progress."

Improvements in vehicle design and traffic engineering have clearly played a part in keeping road accidents down, and with more research, surely even greater and more energetic contributions should be expected and demanded from these two sources. But the greatest single factor is undoubtedly the road. Acceleration of the programme of road construction would appear to be justified for this reason alone. On the normally accepted road of to-day, the driver is called upon to make too many "snap" judgments and surmount too many hazards. The hazards facing the train driver on his well-signalled and unobstructed permanent way are almost nil, and that ideal should be sought on the roads. A close approach to such standards is not as difficult as might at first sight seem to be the case, for no less than 25 per cent of the traffic is carried on as little as 1 per cent of the national road system, and 60 per cent of the traffic is carried on 10 per cent of the road system. Thus, improvements can be concentrated into these sections. Where improvement to motorway standards is, for some reason, impracticable or delayed, minor improvements can sometimes be carried out at critical junctions, as the Road Research Laboratory has shown, with very profitable returns in the form of reduced accidents and reduced delays. This was one of the considerations referred to on Monday, April 11, in the House of Commons, by Mr. Marples, the Minister of Transport, when he opened a lengthy debate on the second reading of the Road Traffic and Road Improvements Bill. The Bill will give the Minister increased powers in handling urban traffic congestion. He pointed out that his Ministry has set up a London Traffic Management Unit and went on: "the idea is that it will deal with London's traffic as a whole and that it will act quickly—as quickly as it can, especially in view of the numbers of cars coming on to the road." Such action will no doubt make a forceful contribution to the road problem, but it needs to be combined, especially in the London area, with a much more energetic programme of road improvement and of construction of new roads. Urban motor roads in London and other cities seem to us one of the essential prerequisites for success in reducing accidents.

DIRECTOR OF THE SCIENCE MUSEUM

There is to be a new director of the Science Museum. On May 1 Dr. T. C. S. Morrison-Scott, the present director, is to become director of the British Museum (Natural History). It is a remarkable tribute to his capability that he has so effectively directed the Science Museum since 1956. For, though he graduated with first class honours in Natural Science at the Royal College of Science, his primary interest has since lain in zoology rather than in physics and chemistry and their applications which predominate in his present post. The goodwill of engineers will go with him and we have the impression that there will be plenty of opportunity for him to show his energy and initiative in his new job. In his place Dr. D. H. Follett, who is at present Keeper of the Department of Electrical Engineering and Communications, is to take over the directorship. We mean no disrespect whatever to Dr. Morrison-Scott in writing that we welcome the appointment to the post of director of one who has had experience in industry—for many years before the war he was with Adam Hilger, Ltd.—and who has had many years of experience within the museum.

We have no doubt that Dr. Follett will find his hands full in the years just ahead. For there is much open to criticism at the Science Museum. One of the troubles is that the museum has always been cramped for space; and even when new buildings now under erection come into service the museum will still remain short of space. For the floor area will still be less than was recommended for the museum by a committee which studied the matter before the first world war. Since then there has been an immense expansion of technological developments. Furthermore modern display techniques need plenty of room relative to the number of objects on view. They also seem to require that what is placed on show for the public shall be backed by many objects, stored out of sight, which are of special interest to historians. What can be done by modern methods of display to present technical subjects and their histories intelligibly to the general public is revealed by certain galleries recently re-arranged by the museum in conjunction with, and very largely at the cost of, industry. We deeply wish that other industries would show similar beneficence. For we suspect that in relation to the real need the amount of money available to the museum for the re-arrangement of exhibits, far less the acquisition of new ones, is almost negligible. It is, indeed, difficult to believe otherwise, because certain deficiencies are obvious enough. Elsewhere in this issue, for example, we print a short comment on a recent publication by the museum entitled *Motor Cars: Handbook of the Collection*. We have felt it necessary to call attention to a number of exhibits that are not in the collection, but which surely ought to be if it aims as it appears to do at complete coverage. We suspect that similar weaknesses in other fields would be revealed were the museum's collections critically examined.

But Dr. Follett's main immediate task must obviously relate to the expansion of the museum into its new buildings, a process which will need careful planning. It will, nevertheless, be interesting to see what happens. For the expansion will provide an opportunity to make changes in the arrangement of exhibits in the older buildings as well as in the newer. What should they be? What they will be, no doubt, will depend largely upon Dr. Follett's assessment of the real purpose of the museum. What sort of place should the museum be? Should it be a place appealing to the public at large, or one intended, especially and somewhat esoterically, for the historian? Should it be given a greater slant towards the display of the history of pure science or of technology? To what extent should it attempt to be contemporary in its exhibits? And to what extent should it attempt to stress the cultural aspects of the applications of science? We have a feeling whenever we visit the museum that no one has ever really thought out a consistent policy for it.

Perhaps Dr. Follett has. Perhaps he has a policy which will make the museum capable of facing the future with equanimity despite the rate of expansion of technological knowledge and practice, and despite the demand of every specialist that every possible item of interest within that specialisation shall be acquired by the Museum and put on view ! But unless he proves able to extract more money than in the past from the Government and from industry we doubt whether he will be able to realise any kind of policy at all. He will be too dependent upon what industry proves ready to do for him.

A SILVER JUBILEE IN STAINLESS STEEL

It is unusual for us to show very much interest in a Silver Jubilee. After all, as centenarians ourselves, we can, we hope, be excused for not regarding the attainment of an age of twenty-five years as especially notable ! But a particular Jubilee which was celebrated last week does seem to us to deserve more notice. In July, 1934, an announcement appeared in this journal and in many others that Thomas Firth and John Brown, Ltd., and the English Steel Corporation, Ltd., had decided to pool their interests in the manufacture of stainless steels. In the following November the merger reached completion, when the new firm of Firth-Vickers Stainless Steels, Ltd., started business. On Thursday of last week the Jubilee was honoured when a large company of people visited the " Staybrite " and the Shepcote Lane works of the firm and subsequently lunched at the Cutlers Hall in Sheffield.

As a result of the amalgamation, the two firms principally interested in this country in producing stainless steels pooled their resources. At the time, of course, the world was suffering from a deep industrial depression and it may well be suspected that financial rather than technical considerations were in the minds of those concerned in bringing the amalgamation about. A degree of competition was eliminated and economies could be foreseen in the costs of research. In the first year of operation, 6000 tons of steel were delivered and the firm had 1400 employees. But more prosperous days lay close ahead and soon the needs of war were stretching production capacity to the utmost. The company developed centri-spinning techniques which made an important contribution both to sleeve valve engine design and jet engine design ; discs and blades for the Whittle engines were made of the firm's materials ; and quantities of bar were supplied for aero-engine valves and tank welding rods. The return of peace allowed only a temporary, though a very upsetting, let-up. Production dropped from over 20,000 tons per year in 1944 to only 11,000 tons in 1945 and 1946 ! Yet remarkably enough it was during those depressing years that Mr. Holmstrom, late managing director, began to point out with growing confidence what a splendid future there was for stainless steel products, not only in the chemical and dairy industries but in the domestic field, too (as, for example, in the kitchen sink), in automobiles and for a variety of household uses. Thus, despite the low immediate demand, the Shepcote Lane site was bought in the second of those depressing years, 1946 ; and although the total ingot demand for all types of stainless steel from all makers was only 70,000 tons in 1948, it was in that year that the decision was taken to go ahead with the plan and construction was started. A subsidiary company, Shepcote Lane Rolling Mills, Ltd., was therefore formed, some of whose equipment was installed as recently as last year. Samuel Fox and Co., Ltd., has a one-third interest in that company. The finished products of the company are supplied in the forms of sheet, strip, bar, castings and forgings ; and it is an indication of the rapidity of development of the uses of corrosion-resisting and heat-resisting steels that more than forty different types are now made. Present output capacity has reached 40,000 tons per year and employees number 4200. There are now two main categories of stainless steels. The martensitic or plain chromium steels owe their properties to a high percentage of chromium and are capable of being hardened by heat treatment. The austenitic steels contain both chromium and nickel and other alloying elements and cannot be hardened ; but they are ductile and easy to manipulate and weld. The confidence of Mr. Holmstrom has proved amply justified. Taking one year with another, the demand for flat stainless products appears to double every ten years or so. The engineering industries are large users of these materials and we confess to finding it difficult to understand how in the past engineers managed to get along without them.

The Engineer—100 Years Ago (APRIL 13, 1860)

" MARINE ENGINE PROPORTIONS "

" The increased pressures at which marine engines are being worked is being attended with corresponding changes in the proportions of the boiler, and better views on the subject of combustion are leading to the allotment of more space over the fire-bars. The adoption of an artificial draught for boilers working with distilled water, will still further modify their proportions . . .

" Under the improvements which have now acquired such momentum, the present enormous weight of marine machinery will be very greatly diminished, and some room will be left for cargo, of which an enormous ship like the Persia can now carry only 500 tons. Although, in still water, a ship goes faster in proportion as the power is increased, there is such a thing as overpowering a steam vessel, or, more properly speaking, as overloading her with machinery. In a head sea, it is often impracticable to work at full power without drowning the decks, and in such cases, a boat with comparatively heavy engines and boilers cannot go as fast as another with lighter machinery—the surplus in the first case being, in fact, so much dead weight, telling heavily upon the vessel's displacement. Whatever the excellence of workmanship of engines and boilers upon the old plan, from one-third to one-half of their power is expended in carrying themselves, or the displacement which they represent, through the water. Surely there is something in this waste worthy the attention of economists, and a properly-constructed vessel under a little commonsense engineering might, indeed, win a brilliant reputation under the name of the ' Economist.' "

The Great Western Railway and Its Personnel

By H. HOLCROFT

No. III—(*Concluded from page 597, April 8*)

Administrative reorganisations at the beginning of the railway grouping period paved the way for the fullest expansion of the Great Western Railway Company in the years before the second world war. This concluding instalment deals with the active development policies which, while giving ever-improving service to passengers and traders, also earned a reasonable dividend for the ordinary stockholder. Among engineering matters, the author analyses the events leading to the decision to build the "King" class locomotives.

WHEN Pole took his seat as general manager in June, 1921, he had ahead of him two pressing tasks. The first was to restore the company to financial stability, for Government control was to end in August, and it was known that the railways were being operated at a loss, although the shareholders had received a dividend of 5¾ per cent throughout the war years and 7¼ per cent after. The outlook was not

Sir Felix Pole, general manager from 1921 until 1929

reassuring, but there was a feeling of relief that the company would regain control of its own affairs, and the officers and men were eager to show what could be done.

The second task was to weld into one organisation the seven constituent and twenty-six subsidiary companies which from January 1, 1922, would constitute the enlarged Great Western Railway.

In dealing with the financial situation, the Chief Officers' Conference was the most potent instrument. It was decided to have monthly meetings of the conference at which the position of each department would be discussed. At these meetings each chief officer was to be given a target and, as a start, all items of expenditure which were more than 200 per cent above the 1913 total were to be investigated. At the same time it was decided to re-introduce canvassing for traffic, which had been in abeyance during the war, and thereby augment receipts. Excellent results followed, for not only did receipts from traffic improve, but many economies were effected and net revenue increased to such an extent that, after making full provision for renewals and depreciation, a satisfactory balance was available for the payment of dividends which were fully earned, being at the rate of 8 per cent for the years 1922 and 1923. The rate for the following three years was affected by various strikes, terminating in the General Strike of 1926.

Post-war conditions were tackled with energy with the object of increasing the efficiency, cheapness and popularity of the G.W.R., and every effort was made to restore passenger and freight services to the standard attained prior to the war. Departmental organisation was streamlined by amalgamating the accounting and audit departments under the chief accountant. This was followed by combining the surveyor's and the rates and taxes departments, and by abolishing the electrical department and transferring electrical matters, other than those pertaining to the department of the signal engineer, to the chief mechanical engineer with a view to encouraging electrification.

There was evidence of over-centralisation. For example, the distribution of rolling stock was arranged at headquarters by the superintendent of the line. No station master or local officer could make use of a wagon or coach without authority from headquarters; the divisional traffic officers had no control over the rolling stock inspectors, who, although located at various stations throughout the line, were responsible direct to headquarters.

This was all changed, and the traffic division was made the unit for distribution of rolling stock, the superintendent of the line retaining over-riding control. At the same time, the rolling stock inspectors were transferred to the control of the respective divisional superintendents.

The Great Western was organised on the departmental system; that is to say, each department was self-contained and controlled by a chief officer, under whom were divisional officers, each responsible for a considerable area of the railway. These departments had grown and developed with little regard for other departments. For instance, the division of a divisional superintendent might overlap three or four district goods managers. The respective officers were unable readily to get together with their "opposite numbers" in the other departments and this entailed wasteful correspondence and unnecessary time spent in travelling.

The general manager called a conference of chief officers, and the whole organisation was reviewed from the point of view of efficiency and economy. It was decided as a matter of principle that the areas supervised by divisional and district officers should be co-terminal, and to increase efficiency and reduce correspondence the officers in each area should meet in conference regularly.

The distribution of divisions and districts in the traffic, goods, locomotive and engineering departments were examined and a scheme formulated for their redistribution to ensure that the geographical limits of divisions were the same for all four departments. This was achieved without addition to the locomotive and engineering divisions, by allocating, where necessary, two or more divisions of one department to one of another.

Local conferences were held monthly of the traffic, goods, locomotive and engineering officers. The agenda embraced statistics of operation and expenditure, suggestions for effecting economies in operation and more economical use of rolling stock, improvement of services and facilities, new works schemes, &c.

The problem of welding together the lines amalgamated with or absorbed by the Great Western at grouping proceeded by stages. Other than on the G.W.R., the various boards of directors, general managers, secretaries and other chief officers disappeared,

Lord Churchill, chairman of the Great Western Railway Company, 1908-1933

but other officers were given posts with the new Great Western Company.

Many officers retired, for the generous scale of compensation laid down in the Railways Act was an inducement to do so, but it was quite justifiable in view of the considerable economies effected. Others not affected by this offer took the opportunity to retire, and among these was Churchward. The writer heard it said that somewhat earlier on there was some heated controversy at a meeting of a sectional board held under the conciliation scheme at which he was present. One of the trades union members tartly reminded Churchward that he was no longer master in his own house; after a short pause Churchward exclaimed wearily, "I can see it is high time the Old Man retired!" This he did at the age of 64.

The idea of a large Great Western "family" had often been mentioned by the Chairman, Lord Churchill, and in pursuit of this ideal Pole attended as many staff functions as

possible. The *Great Western Railway Magazine* of which he was at one time editor, played an outstanding part, and, although there was no actual department devoted wholly to welfare work, much was being done by the provision of hundreds of houses in various parts of the system ; through the Social and Educational Union, the development of debating and other societies, the ambulance movement and the Helping Hand Fund.

The general manager and other officers in presenting awards were able to spread the " family gospel " and to bring home to each individual the part he had to play in promoting the well-being of the company. Direct appeal was made to every employee, by means of leaflets, in matters such as the need for each to economise in materials, stores, stationery, and so on, to the extent of 6d. a week ; at this rate an annual saving of over £100,000 would result.

A New Year's greeting and a leaflet to give information on the company's policy and activities were sent to every employee.

The general manager also attended functions of trading bodies, such as Chambers of Commerce and other trade associations. This gave an opportunity of speaking to large bodies of traders in proposing or responding to a toast and of saying something to enhance the company's reputation. The fact that on the average at that time a railway goods vehicle made one loaded journey in four days was enlarged upon and brought home to traders, and so much was done to expedite the movement of traffic.

Experience in using 20-ton four-wheeled coal wagons for the conveyance of coal for the company's locomotives was found to be advantageous and to be preferable to the use of 40-ton bogie wagons. In 1923 owners of coal wagons in South Wales were invited to introduce 20-ton wagons when making renewals. It was pointed out to them that the cost of constructing two 10-ton coal wagons was about 50 per cent more than the cost of building one 20-ton vehicle. In addition, the need for more siding accommodation at the collieries would be obviated, while the cost of repairs to wagons and sidings would be reduced.

As there were over 100,000 private owners' coal wagons in South Wales, mostly of 10-ton capacity, it was obvious that the introduction of 20-ton wagons would effect a very large saving on the annual cost of renewals, although it was recognised that some difficulties would have to be overcome at the collieries and at the docks. The company offered to allow a rebate of 5 per cent off their rates in respect of coal class traffic conveyed wholly over their system in fully loaded 20-ton wagons, notwithstanding that railway operating economies would not accrue until a considerable number of high-capacity wagons were in use. Considerable progress was made in the course of the next few years and, as a further inducement, dock charges for the shipment of coal conveyed in fully loaded 20-ton wagons were reduced.

Delays to freight sometimes occurred and occasionally annoyance was caused to traders when consignments did not arrive within a reasonable time. Pole proposed a scheme, based on the Post Office registered letter system but designed to meet the wishes of traders, whereby they would be advised when any particular consignment was delivered, especially in the case of goods for shipment. It was proposed that on payment of a fee the railway company should undertake to watch the movement of particular consignments throughout the journey and guarantee to deliver by a specified time.

The scheme was submitted to the Railway Clearing House, but various objections were raised, so the Great Western went on with the scheme as far as its own system was concerned. It proved very popular and in the course of time the other railways adopted it under the slogan " Register under the Green Arrow."

Elias Ford, the goods manager, was most energetic in evolving ideas for improving goods services. As regards ordinary deliveries, his aim was to convey all consignments in one day, and this was made evident to the public by slogans such as " One Day Transit to all Points," painted in large letters on the roofs of goods stations. He was also an enthusiastic advocate of what became known as the " railhead method of distribution," which was the establishment by large firms of a stores depot at central stations for retail deliveries to be made by the G.W.R. as agent for the company concerned. Many well-known firms made extensive use of this system.

Combined rail and road services were gradually extended and arrangements

C. B. Collett, Churchward's successor as chief mechanical engineer in 1922

developed to collect and deliver goods traffic within a radius of 15 miles from certain stations.

Charles Aldington, as superintendent of the line, had been a keen advocate of longer coaches, and some of these were 72ft in length. On relinquishing his post as general manager, he urged Pole not only to continue to favour long coaches, but to introduce even longer ones. C. B. Collett, who became chief mechanical engineer in January, 1922, was against this, as he felt the limit of safety had been reached as regards buffer locking on sharp curves. He thought it better to reduce the length of new coaches to less than 70ft, and this was agreed to.

In his efforts to improve rolling stock, Collett carried out some research. There were seven different types of bogie in use, so he arranged for a train of seven coaches to be assembled representing all the different types of bogie. This train was run at high speed, and it was found that, while certain of the coaches were comfortable, others were unsteady and even alarmingly so.

Pursuing the experiment, Collett arranged for the lavatory tanks of the seven coaches to be filled, each with a wash of a different colour. An observer was stationed in each lavatory with instructions to release some wash whenever a bad lurch was felt. If only one or two observers felt a bump it might be assumed that the coach was at fault, but when all the observers did so, and the section of track looked like a rainbow, it pointed to defective permanent way, such as places where sleepers were defective or the packing needed attention. This " whitewash " train became a regular feature of permanent way examination.

In order to observe a bogie in motion, part of the floor of the guard's van was removed. While this helped in developing a new bogie, the defeaning noise at speed also indicated that to ensure comfort of passengers the floor of all coaches needed to be insulated and made as sound-proof as possible.

In due course Collett produced a standard bogie intended to replace all other types ultimately. It was known that in order to run steadily, coaches having similar bogies should be together as far as possible. In order to make the new bogies apparent to shunters and others when assembling trains, a clear indication was given by painting the axleboxes blue.

On becoming chief mechanical engineer in 1922, Collett had refused to move into " Newburn," the official residence, having an aversion to the place, and so Churchward continued to occupy it until his tragic death in 1933. After that, the building was demolished and additional sidings laid over the site where this noted house and its grounds had been.

Collett faithfully carried on Churchward's locomotive standards and practice and enlarged upon them. As the civil engineer had refused to accept the " Star " class (four-cylinder 4–6–0) for running if provided with Churchward's No. 7 boiler, on account of excessive weight, Collett set about designing his No. 8 boiler, intermediate in size between Nos. 1 and 7. By doing so, he was able to mount it on an enlargement of the " Star " class chassis, and to keep the weight imposed by each pair of coupled wheels below 20 tons as desired by the civil engineer. The resultant locomotive, the famous " Castle " class, which first appeared in 1923, was outstanding in its performance for speed and haulage, and brought much prestige to the G.W.R. Batches of these engines were built at intervals over the next twenty-five years, and their construction only ceased with nationalisation.

As the " Castle " could easily deal with any train that could be accommodated in the length of platforms at Paddington as they stood at that time, it came as a surprise when an even larger four-cylinder engine, the " King " class, made its appearance in 1927. There seemed to be no very convincing reason for its creation only four years after the " Castle." The events leading up to it and the circumstances in which a decision was made to go ahead are dealt with in *Pole's Book* in the chapter headed " Birth of the King George V Locomotive."

(It may be interposed here that Pole was knighted by H.M. King George V, his name being included in the Dissolution Honours List of 1924. Hereafter he is referred to as Sir Felix.)

It was one of the directors, Sir Aubrey Brocklebank, chairman of the locomotive committee of the board, whose knowledge of locomotive practice was considerable, who in the course of conversation with Sir Felix indicated " that locomotives of the ' Castle ' class were not entirely satisfactory." Apparently this referred to their limitation in

axle loading, the maximum permissible at that time being 19½ tons, and full advantage had been taken of this in the design of the "Castle." They discussed the point with Collett, who lamented the fact that, compared with axle loadings in America, British locomotive practice was badly hampered, and he added that if he could work to an axle load of 22½ tons he could produce a very fine locomotive!

Sir Aubrey then discussed various limiting factors in railway affairs and he contended that the rails, if adequately supported, could carry almost any weight and so the difficulty must be in the bridges; and he asked if a diagram could be prepared to show the maximum axle load for each bridge. At this, Lloyd, the then chief (civil) engineer, was invited to join in the discussion and he readily agreed to have the diagram prepared. When asked what axle load he provided for in designing new bridges, he replied 22 tons, which caused some astonishment, especially as it transpired that it had been standard practice for over twenty-two years, having been recommended to the engineering committee by Sir James Inglis when chief engineer.

On inquiry whether the original calculation had a sufficient factor of safety to permit 22½ tons axle loading, Lloyd assented, and he estimated that there could only be a few bridges on the main line that had not been renewed in comparatively recent years. Upon this, Sir Felix turned to Collett and said: "You can build a new locomotive having an axle load of 22½ tons and we will have it for the summer traffic of next year." To Lloyd he said, "You must have the line from London to Plymouth ready for the new locomotive." In giving these instructions, Sir Felix must have felt confident that the board would endorse his action.

Upon investigation it was found that only some four bridges had to be reconstructed, the largest being over the River Kennet at Reading. Thus it came about that in July, 1927, the birth of "King George V" was announced. It had a maximum tractive effort of over 40,000 lb, which was considerably greater than any other British passenger locomotive.

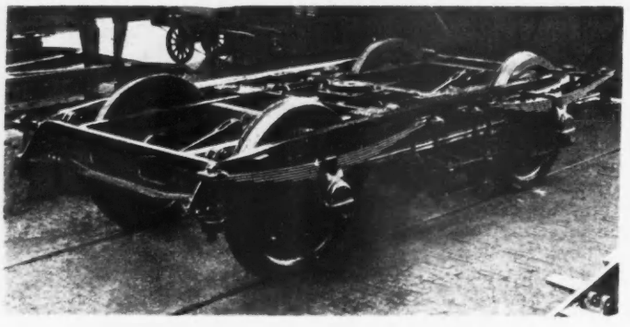
Sir Felix went on to say that a critic of railway management might well comment on the fact that neither the general manager nor the chief mechanical engineer knew that for twenty-two years bridges were being designed to enable heavier loads to be carried. This was quite in keeping with the highly departmentalised state of affairs that existed at Paddington, and there was little doubt that the then general manager and the superintendent of the line were not even aware of what the directors had authorised as the basis for future engineering practice!

Railway engineers, both mechanical and civil, will recognise that the account as related in *Pole's Book* is an over-simplification of a very complex problem and that it represents less than half the story.

The Railway Engineers Association, which included all the civil engineers on railways in Great Britain, had its counterpart in the Association of Railway Locomotive Engineers. These two bodies could discuss points of common interest, and one of the results of such collaboration was the adoption of a standard tyre profile to supersede the many variations in use. The R.E.A. load curve of 1908, which showed a maximum axle load of 22 tons, was well known to the A.R.L.E., as well as the later one of 1920, which also permitted 22 tons. This maximum, however, represented a rolling load upon the underbridge and a margin had to be allowed for various dynamic loadings, in particular the hammer blows set up by the revolution of coupled wheels of locomotives at speed. In order to safeguard his structures, the civil engineer on the Great Western had hitherto restricted the weights on coupled wheels of locomotives to 19½ tons.

Churchward's Pacific type "The Great Bear," of 1908, had 20 tons on each of the coupled wheels, but its running was restricted to the main line between Paddington and Bristol. His proposal to mount his No. 7 boiler on the "Star" class was refused, while Collett had to keep to 19½ tons for his "Castle," although all three of these classes were four-cylinder engines.

This rigid attitude had long been maintained by the chief engineers and yet only three years after the "Castle" had appeared Lloyd seemed to accept without demur a loading of 22½ tons. No wonder Collett was astonished!



Collett's 9ft standard pressed steel bogie for passenger coaches

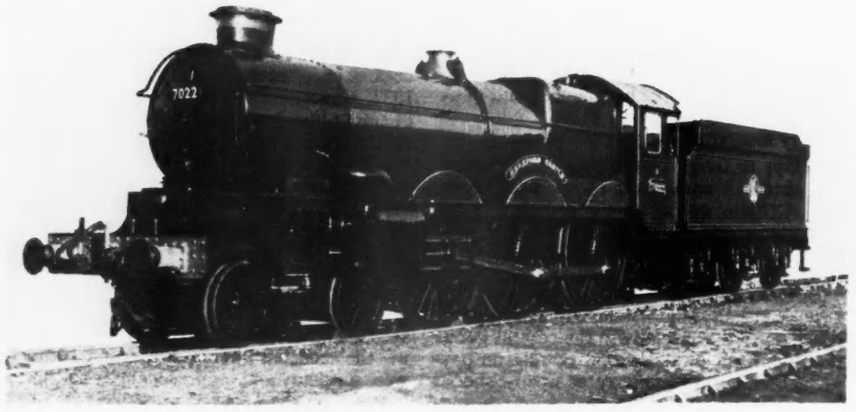
It may well be asked what it was that caused this change of attitude and the reason for Sir Aubrey Brocklebank's inquiries into axle loading. The writer submits that it was the appearance on the Southern Railway of the four-cylinder 4–6–0 type engine "Lord Nelson" in the summer of 1926. Not only had this engine more nominal tractive effort and a boiler with a larger grate area than the "Castle," but the weight carried by each pair of coupled wheels was close upon 21 tons. The chief mechanical engineer of that railway held the view that the very light or even negligible hammer blow in multi-cylinder engines merited some increase in static loading as compared with that of engines having two outside cylinders. This view was strongly pressed with the civil engineer with the result that an increase of 10 per cent was permitted for multi-cylinder engines above the 20 tons limit in the case of two-cylinder engines.

No doubt Sir Aubrey thought that if the Southern Railway could allow such loading, the Great Western should at least equal, or even exceed it, hence his inquiries into axle loadings. It is possible that he had some preliminary talks with the parties interested to pave the way before approaching the general manager on the subject. The outcome of it all was that, according to his account, Sir Felix gave instructions out of hand for the building of a new locomotive having axle loadings of 22½ tons and the immediate renewal of any bridges incapable of carrying it. It should be noted, however, that the concession over axle loading only applied in the case of a four-cylinder engine.

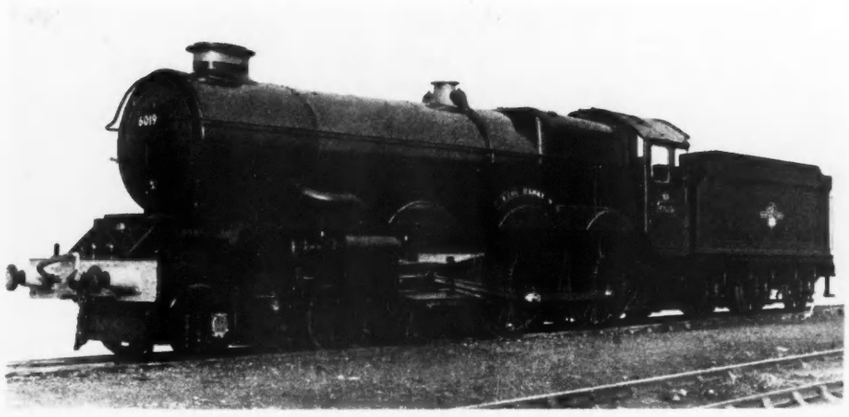
Not only was the "Castle" outstanding in its performance on the Great Western, but in the interchange of locomotives in the trials of 1925 an engine of this class showed to advantage against Gresley's Pacific type on the London and North Eastern Railway. In the summer of 1926 a locomotive of the "Castle" class was lent to the London Midland and Scottish Railway for trials between Euston and Carlisle. This engine handled with ease trains which were causing the L.M.S.R. engines to lose time or need double-heading.

It may well be asked why, in view of all this, it was so urgently necessary to build the "King." The writer suggests that it was largely a matter of prestige, for the fifteen years' lead over other railways which Churchward had established in 1911 had been overtaken and something drastic was needed to regain the lead. No sooner had the first of the class, "King George V," run its trials than it was shipped to the United States to take part in the centenary celebrations of the Baltimore and Ohio Railroad in a blaze of publicity.

The only routes available to the "Kings" were Paddington to Plymouth, and Paddington to Wolverhampton via Bicester, and



A "Castle" class locomotive as running to-day with double-blastpipe chimney



Like the "Castles," the "Kings" have been equipped with double-blastpipe chimneys but otherwise are little altered in appearance

no more than thirty of this class were built. After that, the building of "Castles" was resumed and continued for another twenty years.

Collett did not continue with the building of Churchward's "Saint" class, two-cylinder 4–6–0 type with 6ft 8½in wheels for express work. Instead, he altered the design by adopting 6ft wheels, so creating a general utility engine which proved to be highly successful. This was followed by a similar engine with 5ft 8in wheels for fast freight trains, the "Grange" class, also having a large route availability. To cover the remainder of the system, the lighter "Manor" engine of the same type was produced.

The Cambrian Railway, taken over at the grouping, presented a problem, for conditions were very similar to those prevailing in Devon and Cornwall after the disappearance of the broad gauge. Collett solved this problem by re-constituting from existing engines Dean's "Duke of Cornwall" class of 1895, which had done so well there, for use in another field. This 4–4–0 class carried on until the "Manor" class came to supersede it.

Sir Felix Pole had long felt the need for an authentic history of the Great Western and the opportunity came during conversation with a Great Western enthusiast, E. T. McDermot, a barrister by profession. He indicated that he would gladly accept a commission to write such a history. His offer was accepted and the directors gave him access to the records of the company. He had a free hand to state the plain unvarnished truth, without fear or favour.

It was in the autumn of 1928 that Sir Guy Granet, in the course of conversation, asked Sir Felix whether he had ever thought of leaving the Great Western, to which he replied that he had not and would never do so. Sir Guy said that he left the Midland Railway and had not regretted doing so. He went on to say that a new electrical company had been formed for which a whole-time chairman was needed, and that Sir Felix might at least have a chat about it.

This matter having been broached, Sir Felix received a call from one of those who had formed the new company, but as little was said on this occasion it seemed as if it were the end of the matter. This was not the case, for friends of Sir Felix interested in the new company pressed him to make the change. In due course he told the chairman, Lord Churchill, what had been offered and said he would refuse it if the chairman wished him to do so, but there was something to be said for acceptance as it would give Milne, the assistant general manager, his chance.

In July, 1929, Sir Felix took up his work as chairman of Associated Electrical Industries, Ltd., and James Milne was appointed general manager of the G.W.R. They had been friends for some twenty years and in recent times their association had been rather in the nature of a partnership than that of chief and assistant. Sir Felix could, therefore, hand over the reins of office to him confident that he would handle them skilfully and well, and that he would ably maintain Great Western traditions.

At fifty-two years of age, Sir Felix had the prospect of many years ahead of activities in new fields. His departure gave Milne (later Sir James Milne) his chance to move up; there was only some five years between their ages.

The Great Western Railway Company had by this time expanded to its fullest extent; the organisation had been overhauled and streamlined and was in the position to give the passenger and trader ever-improving service and facilities, while earning for the ordinary stockholder a reasonable dividend. This continued until the autumn of 1939, when the second world war broke out and the Railway Executive Committee once more took over control.

This arrangement lasted for nearly six years, and at its end a Socialist government came to power with State ownership as its policy. The plan to nationalise the railways was not long in coming, and as the New Year of 1948 was ushered in the great company came to its end.

The Parking Problem

(Contributed)

IN this article further reference is made to the Traffic Engineering Study Group's discussion on "Parking" at the Institution of Civil Engineers on March 29, about which we published a report last week.

The problem of providing parking space at places of work, for the employees' own vehicles, was raised by a speaker, who told of a recent survey covering thirty firms, in different parts of the country, employing from sixty to 4500 persons, the average being 450. At these firms' premises the overall ratio of personal vehicles to employees worked out at: bicycles, one in five and a half; cars, one in twelve; motor-cycles, one in twenty-three; motor-cycles with sidecars, one in 170. Already more than 60 per cent of the firms were embarrassed to find space for parking on that scale; but the demand is increasing. The point was made that industrial parking is fast becoming as essential an amenity as the works canteen.

Two aspects of the problem of parking or garaging in residential areas were raised during the discussion. The first concerned council housing estates, where visibly the motor vehicle population is increasing as rapidly as elsewhere. In existing estates it would often be impossible to find sites for the construction of parks without resorting to demolition, which would be a very extreme measure. The other type of area to come under discussion was exemplified by a sector of West Central London, comprising approximately a dozen square miles with resident population 355,000 persons and more than 50,000 motor vehicles. The parking problem is spreading outwards through such near-central districts. In considering the commuter car parking problem it is important not to overlook the existence of an often large, and always increasing, resident vehicle population; the sum total of central and near-central urban space devoted to the stationary motor vehicle can reach a high proportion of the whole—far too high for a recognisably British city—when both car-owning and car-commuting become general—witness Detroit. That prospect led one speaker to mention the rush-hour "exhaust fog" of Los Angeles, and to admit that there might be advantages in the moving of some of the work places out from our cities. Another speaker thought it important to preserve a balance between private and public transport.

The subject was parking; there was plenty to be said on it, and the discussion was quickly piloted back to it whenever necessary. However, since the decline of public transport is concomitant with the parking problem, it was not altogether irrelevant that certain other speakers also touched on the subject of public transport. There was a reminder that 93 per cent of the daily passenger traffic into and out of London is still by public transport. One speaker suggested that a pair of ring roads—the outer one principally for cars, the inner one for buses—could result in a much improved bus service, justifying a considerable increase in the use of "No Waiting" orders in the centre. Against this the view seemed to predominate that public transport should "set its house in order" if it could; but meanwhile, and for the foreseeable future, this is the motor car age.

It remains to record one speaker's distinctive contribution on the nature of the problem. He reminded the meeting that traffic engineers are not as other engineers in the problems they meet; it is not the forces of Nature alone with which they have to contend, but also those of human nature; Nature conforms, humans do not. This particular problem of parking is very typical of traffic engineering in that respect. It is, moreover, typical of the conflicts to which inventions and new developments give rise. These conflicts are either allowed to resolve themselves the hard way, in the field of economics, which in this instance might result in parking becoming altogether too expensive to be afforded by the general run of present-day car owners; or else the conflicts are resolved by the Government of the day by means of legislation that inevitably involves some curtailment of freedom and diversion of resources.

Another speaker averred that current reduction in vehicle usage is not by will of the users, nor for lack of personal spending power; it is due to lack of highways, including parking space.

Data Handling in Air Traffic Control

A one-day symposium on Data Handling and Display Systems for Air Traffic Control was held by the Electronics and Communications Section of the Institution of Electrical Engineers in London on April 8. Nine papers were presented for discussion in two sessions, the first dealing mainly with flight information processing and the second with radar data handling. We summarise below a general survey of the situation presented in one of the papers, and an account of a data handling system now under development. The accompanying illustration shows a current form of control display in the New York centre of the Federal Aviation Agency.

THE first paper in the symposium, "A Survey of Data Handling for Air Traffic Control," was by Messrs. J. C. Farmer and M. F. Whitney of the Ministry of Aviation, and was presented at the symposium by Mr. Farmer. It opened by describing the present method of following the movements of aircraft by means of flight progress strips displayed on a board in front of the controllers. The strips are prepared initially from the pilot's flight plan and amended during the flight on the basis of position messages received from the aircraft giving actual times at the various reporting points, and perhaps requesting changes in altitude or routing, or other modifications of the original plan. The sanctioning of such changes depends on the overall traffic position as seen by the controllers, and must take account of minimum separation distances permitted between aircraft. Separations are lower in areas where aircraft are under radar control, so that liaison is required between the procedural controller at the flight progress board and the radar controller monitoring the aircraft movements on his screen.

The first suggested step for improvement in current procedures is to eliminate the manual writing and multiplication of flight progress strips. Initially, at some location, the flight plan must be typed or preferably teleprinted, and the requirement is for a strip printer or battery of printers which can produce sufficient flight progress strips for all users. Generally only a selection of the information on the flight plan need be displayed on the flight progress strips, and some items should be held back until departure is imminent or confirmed. Conceivably all the functions, including calculation of estimated times at reporting points, could be carried out by some form of automatic data processing and computing, including storage until required. These improvements do not eliminate manual handling of the printed progress strip, and it is suggested that an alternative solution would be a different and automatic display of characters occupying no greater space than the present strips and holders, and brought up to date automatically if possible.

At present the computation of estimated times of arrival is not very time-consuming, but when a number of calculations must be carried out in a very short time, and the results examined for conflict, a far more advanced computer will be necessary. A further stage in the computation could be that the machine, having determined a potential conflict, not only gives warning but makes a number of specified changes in the flight clearance, such as change of altitude or departure time, and repeats this programme until a no-conflict situation is disclosed. A number of alternative solutions might then be displayed to the controller for decision. When all the variables are taken into account, the human eye and brain can probably be trained to appraise these conflicts and solutions better than a machine.

Considerable time might be saved by automatic renewal of positional information on the progress displays. Such information, now received by radiotelephone and written or printed manually, could be transmitted automatically from the aircraft, sequentially or on request, in a form which would be suitable for the computer.

A later section of the paper summarised the special requirements of an air traffic control data processing machine and concluded that such a computer is likely to emerge on the following lines :

(*a*) Multiple, parallel, comparatively slow inputs.

(*b*) Fast read-outs into the main store, thus allowing time for multiple calculations, processing routines and interrupt facilities (i.e. break-in to cope with emergencies).

(*c*) Multiple, parallel outputs, which may be fast or slow, depending on the nature of the display.

The paper proceeded to discuss radar data processing. At present the trend in civil aviation is towards presenting the air traffic controller with a display showing only the aircraft in which he is immediately interested, clearly identified and associated with other relevant information, such as altitude. For this purpose a controller having available all the information from flight plans of intending movements would act as a track allocator, the procedure envisaged being as follows. On observing and identifying the entry of an aircraft into controlled airspace he superimposes a strobing ring on the target by operating a joystick control. Movement of this control generates a pair of voltages proportional to the x and y co-ordinates of the target and these are switched into some form of magnetic store, adding electronically such information as altitude and an identifying code number. He then allocates the target to one of a number of trackers and proceeds to identify further targets.

The chosen tracker now sees on his radar display a synthetic target together with the original, and having a similar joystick control himself, is able to adjust the synthetic target to coincide with the original at frequent intervals, thus resetting the stored co-ordinates. A refinement of this method is for the rate of change of positional voltage to be derived and stored after two or more sweeps of the radar display. By combining the information from the position and velocity stores, it can be arranged that, so long as the aircraft maintains course and speed within reasonable limits, the displayed synthetic target is always so close to the actual target that little or no readjustment is necessary.

The final stage in the operation is for the air traffic controller to select for his own display the synthetic targets he needs. He may select by altitude, within a given area, or according to function as determined by additional information put into the store.

Although the final display of positional information is in analogue form, it is probably an advantage to process the information in digital form. This process lends itself to straightforward computer techniques, which are in any case more suitable for feeding in ancillary information, and the data can more readily be transferred over long distances by landline or radio.

A weakness of the system outlined above is the number of trackers required, and attention is being given to the automation of this element. Two main methods are being pursued. One is to lock one or more auxiliary radar equipments sequentially on to selected targets for a short period and so automatically renew information. The other line of approach is to digitise the positional information and to effect the comparison between the existing stored, velocity-aided

target and the renewed information by computer techniques. If correspondence is within certain preselected tolerances, the existing information can be brought up to date.

The paper concluded with references to improvements in brightness of analogue displays presented to air traffic controllers on cathode ray tubes. A system under development is the direct-viewing storage tube using a flood gun to activate the phosphor, but tubes of this kind currently available are limited to an effective display area of 4in and have a resolution below that of conventional tubes. A second development which shows promise in this field is the tube employing a very thin screen of phosphor which is transparent to incident light. Such a screen would show clearly targets of quite low brightness in high ambient light conditions. Again, considerable further development in manufacturing technique is needed before a tube suitable for air traffic displays is available.

A storage system which is now in use in some countries is the scan-conversion tube, which accepts a radar video input and, after storing and rescanning, produces an output in television form. In another form of bright display a photographic film record of the radar screen is made, chemically developed in a few seconds and projected on to a large screen. The addition of alpha-numeric information to the normal radar display may follow the principle of using part of the timebase for displaying the additional information, either by borrowing one or more complete sweeps (" Intertrace ") or by utilising the flyback period (" Interscan ").

Computer Installations and Projects

After the opening paper summarised above, Ir. C. G. H. Scholten, of N.V. Hollandsche Signaalapparaten, described and demonstrated the " Satco " air traffic control system of which one version is now in operational use at Amsterdam airport. This provides dead-reckoning computations on a system of Cartesian co-ordinates, in which flight may be calculated along any sequence of fixed positions. Teleprinters are used to print the " master record " (a full account of all actions performed by and with the computer) and serve at present as main input devices for all flight messages, basic flight plans, and corrections to them and clearances. Other teleprinters (without keyboards) automatically print the progress strips. In a later phase, however, an electromechanical system will be used for displaying information. The indicators may be built into panels on the display board, each panel representing one airfield or reporting position. A control panel in front of the board will enable corrections and clearances to be inserted by means of push-buttons and keys. After inserting corrections, the operator will press an " execute " button. The computer will then change all indicators in the board affected by the correction.

A paper describing an experimental electronic data-processing system under development for the Ministry of Aviation, to be installed at the Oceanic Air Traffic Control Centre, Prestwick, was then presented by Mr. J. S. MacMullan of Ferranti, Ltd., whose co-authors were Messrs. J. S. Bray and J. A. Llewellyn. The scheme comprises a central storage and data processing unit connected to various input and output units, the majority of which are lightweight keyboard teleprinters operating at up to seven characters per second.

The central computer is a fixed-point parallel machine using transistors throughout. Over 80 per cent of the instructions available to the programmer are executed in less than 8 microseconds ; multiplication and division require 60 microseconds. Each storage unit can hold 4096 twenty-four-bit words and each word can hold four alphanumeric characters. With 100 aircraft in the experimental system, one unit will hold about 3200 words of active data, while the other will hold 1600 words of background data and about 2000 words of programme. Additional core units, magnetic-tape units or magnetic drums may be attached to the central computer to increase storage capacity.

Flexibility of the peripheral organisation is assured by an interrupt transfer feature in the central computer, whereby a short sequence of stored instructions for control of input and output can be interpolated into an unrelated current programme on receipt of signals from a peripheral unit. This feature is also the basis of a time-sharing facility which enables the computer to be used by an independent operator for programme development and statistical analysis concurrently with air-traffic control operations. This is possible because, although peak utilisation is high in the latter role, mean utilisation is relatively low. Additional units for time-shared operation include a teleprinter and paper-tape readers and punches.

The objectives in the first instance are : (*a*) to eliminate from the flight progress display all data which are not currently of interest to controllers ; (*b*) to eliminate the routine manual task of initially writing out flight progress strips ; these will be produced automatically by four special teleprinters connected to the central computer. The set of strips required for each flight will be printed approximately half an hour before the estimated time of arrival of the aircraft at the first reporting point in the control area. In order to do this, the central computer will receive regular time signals from an external source and will maintain an up-to-date internal record of current G.M.T.; this record will be referred to by the programme for control of strip printing.

The following facilities will be available to the four controllers using the experimental system :

(*a*) Selection and display of progress or flight/departure plan data on specified flights. Flights will normally be specified by the controller's serial number or by aircraft identity, but it would be possible, for example, to request data on all aircraft within specified limits of altitude and/or arrival time at a specified reporting point.

(*b*) Insertion of clearances and re-clearances. This will be necessary on all flights in order to keep the stored flight progress data in the central computer up to date and in agreement with the manually amended flight progress display.

(*c*) Notification of position reports received or overdue. This will be initiated automatically by the central computer, using a programme in which current G.M.T. is compared with the estimated arrival time of each flight at the next reporting point to detect overdue reports.

(*d*) Notification of potentially conflicting flight paths. A potential infringement of separation standards implied by the stored data will be detected automatically by a special programme in the central computer, and the relevant details will be displayed to the controller responsible. This programme will be initiated automatically on input of re-clearances and position reports, and also prior to output of flight progress strips.

Each controller will have a keyboard and teleprinter for sending instructions to the computer and a page teleprinter for receiving output data. He will also have an experimental display which is being developed by the Ministry of Aviation, presenting up to 200 characters on an infinite-persistence cathode ray tube.

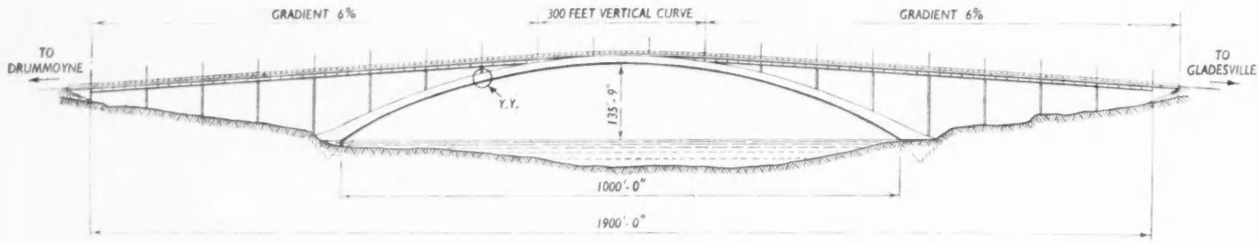
Provision will be made for obtaining from the computer on demand all the data required, in punched tape form, for periodical transmission by teleprinter to the Gander control centre. Traffic checks with Shannon will be similarly assisted.

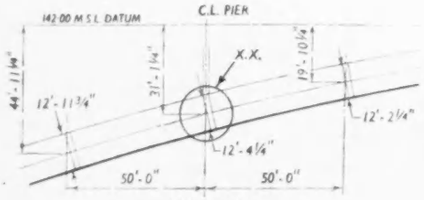
Although experiments with data links will be carried out in due course, the experimental system will depend in the first instance on manual operators, or communicators, for the input of basic data. There will be four communicators, two handling input of flight plans, departure plans and actual departure times, while two will handle input of position reports. The computer programme for input of actual departure time will also automatically convert the stored flight plan accordingly.

An experimental control system comprising the data-processing equipment, four communicators and four controllers, will be set up at Oceanic Centre early in 1961. The " open loop " performance of this system will initially be studied by operating it in parallel with the existing operational one ; it will process and interpret the same incoming traffic data, but will have no executive authority and will not issue re-clearances. Later, the closed-loop performance of the system will be studied with simulated air-traffic data ; controllers will issue re-clearances to, and receive position reports from, additional operators introduced to represent aircraft pilots.

The final paper at the session on data handling was presented by Mr. R. F. Cleaver of Standard Telephones and Cables, Ltd., whose co-authors were Mr. P. Sothcott of the same company and Group Captain F. J. Robinson of the United Kingdom Air Traffic Service Headquarters. It described an automatic radio triangulation system operating in this country in which lines of bearing on an aircraft transmission are automatically measured, transmitted to a control centre and displayed on a map with an overall delay of less than one second. A film was shown illustrating the system in use for directing a fighter aircraft to the nearest airfield in an emergency, fixes being plotted on the normal r/t transmissions from the aircraft.

In the second session an experimental system for automatic detection, extraction and encoding of search plot data from two-dimensional radar displays was described in a paper by G. L. F. Hinckley, of the Royal Aircraft Establishment. In this scheme Cartesian plot data are transmitted for remote use over long distances using a single telephone circuit. Messrs. C. C. Fielding and J. G. Gibbs, of the Royal Radar Establishment, presented a paper on semi-automatic flight control using extracted radar data, for situations where it is doubtful whether a completely manual system could operate efficiently. Automatic and manual tracking were compared operationally in a contribution by N. J. Smith and B. W. Oakley, also of the Royal Radar Establishment. Other contributors from this establishment were Messrs. N. J. Smith and P. F. Heggs, who described a method of displaying tracks and other information on a P.P.I. tube after extraction from a store ; and W. F. Ashton, whose paper dealt with a fixed-coil display system for data extraction.





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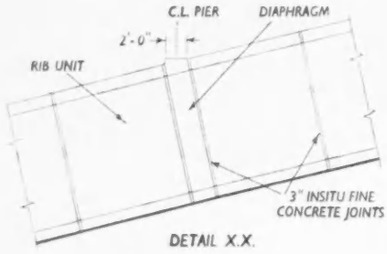

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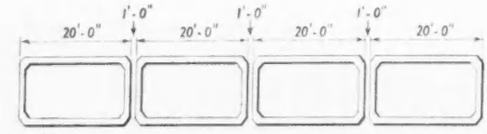
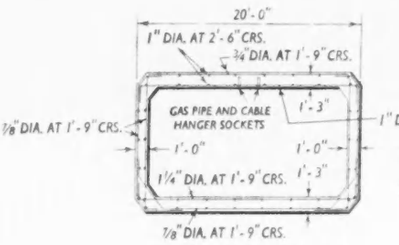
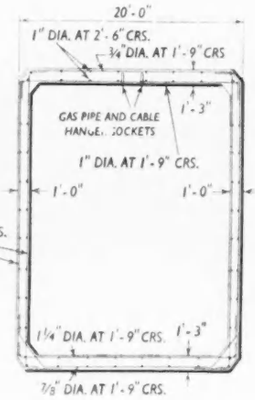


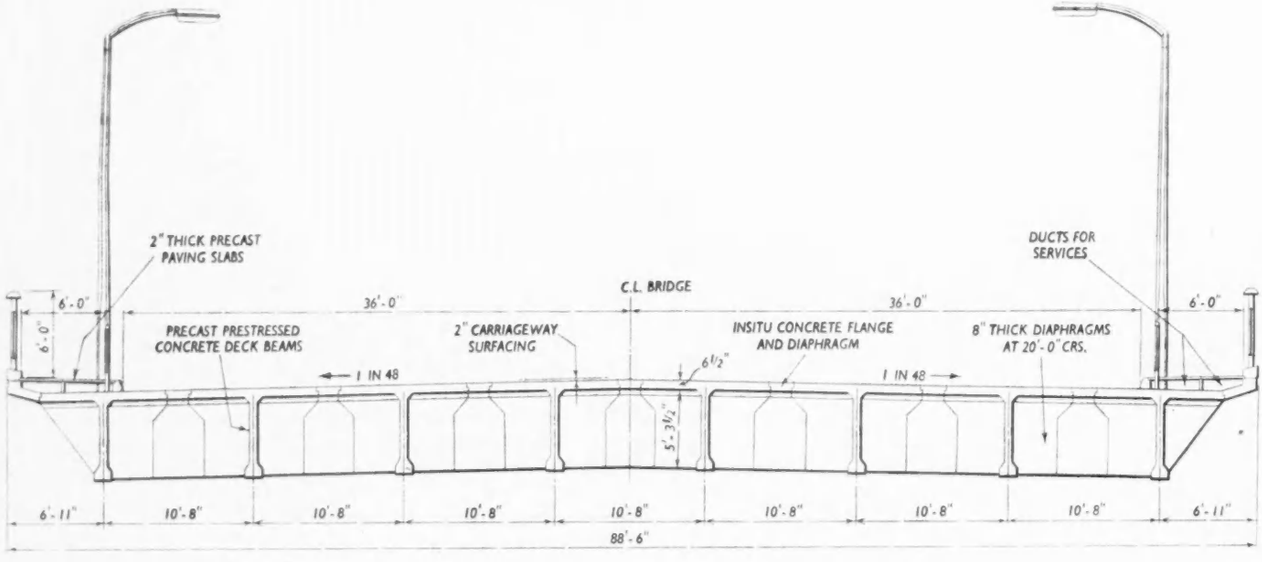
CROSS SECTION SHOWING RELATIVE POSITIONS OF FOUR ARCH RIBS.

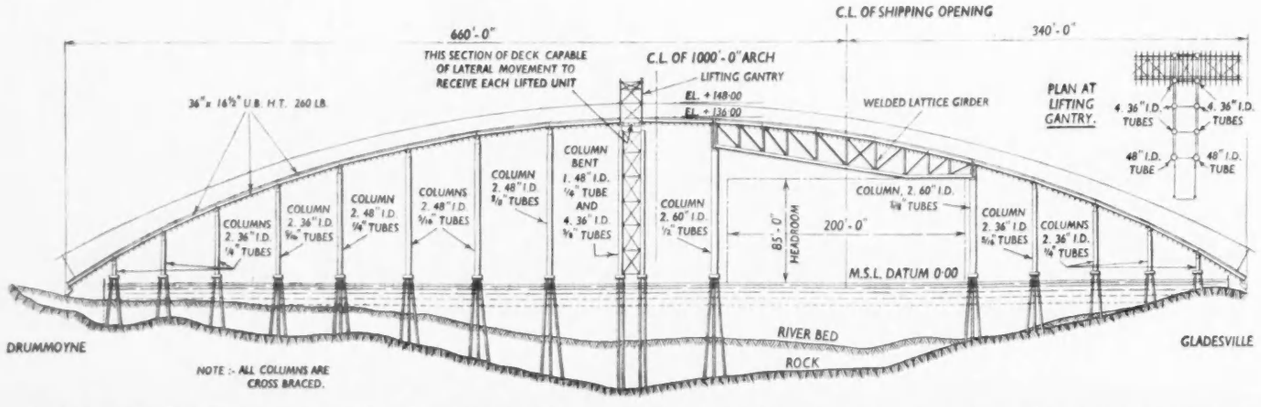

20'-0"
1" DIA. AT 2'-6" CRS.
¾" DIA. AT 1'-9" CRS.
GAS PIPE AND CABLE HANGER SOCKETS
1'-3"
⅞" DIA. AT 1'-9" CRS.
1" DIA. AT 1'-9" CRS.
1'-0"
1'-0"
1¼" DIA. AT 1'-9" CRS.
1'-3"
⅞" DIA. AT 1'-9" CRS.
ALL TRANSVERSE BARS TO HAVE 2" EXTERNAL COVER. 1½" INTERNAL COVER.

SECTION OF ARCH RIB UNIT NEAR CROWN.



SECTION OF ARCH RIB UNIT NEAR ABUTMENT.




C.L. OF SHIPPING OPENING
660'-0"
340'-0"
THIS SECTION OF DECK CAPABLE OF LATERAL MOVEMENT TO RECEIVE EACH LIFTED UNIT
C.L. OF 1000'-0" ARCH
LIFTING GANTRY
EL. +148·00
EL. +136·00
WELDED LATTICE GIRDER
PLAN AT LIFTING GANTRY.
4 36" I.D. TUBES
4 36" I.D. TUBES
48" I.D. TUBE
48" I.D. TUBE
36" x 16½" U.B. H.T. 260 LB.
COLUMNS 2 36" I.D. ⅛" TUBES
COLUMN 2 36" I.D. ⅜" TUBES
COLUMN 2 48" I.D. ¼" TUBES
COLUMNS 2 48" I.D. ⅜" TUBES
COLUMN 2 48" I.D. ⅝" TUBES
COLUMN BENT 1 48" I.D. ¼" TUBE AND 4 36" I.D. ⅜" TUBES
COLUMN 2 60" I.D. ½" TUBES
COLUMN 2 60" I.D. ⅝" TUBES
COLUMN 2 36" I.D. ⅝" TUBES
COLUMNS 2 36" I.D. ¼" TUBES
85'-0" HEADROOM
200'-0"
M.S.L. DATUM 0·00
RIVER BED
ROCK
DRUMMOYNE
GLADESVILLE
NOTE :- ALL COLUMNS ARE CROSS BRACED.

Details of the Parramatta River bridge at Gladesville. The upper view is an elevation of the bridge. Below it are shown details of the concrete arch and of the deck structure. The lowest view shows the centering which will carry one arch rib, and will thus be moved across successively as the four ribs are built

Parramatta River Bridge, New South Wales

Our heading illustration is an artist's impression of the Gladesville bridge, which is to be built across the Parramatta River, an arm of Sydney Harbour, for the Department of Main Roads of New South Wales. The main span will be a concrete arch of 1000ft. This design gave the lowest tender and was accepted as an alternative to the official design in steel. British consultants and one British and one Australian contractor are co-operating in the scheme.

THE new bridge to be built over the Parramatta River, an arm of Sydney Harbour, will have a reinforced concrete arch spanning 1000ft which, it is believed, will be the longest single-span concrete bridge in the world. The arch will be constructed as four parallel ribs, each consisting of a box-section 20ft in width and varying in depth from 12ft at the crown to 23ft 6in at the springing. The ribs will be precast in pieces weighing approximately 50 tons, taken to the site and set upon centering, and joined with *in-situ* concrete. Details of this form of construction can be seen in the drawings on the opposite page.

In order to ensure that, on completion, the arch profile is undistorted, provision will be made for jacking at the two points of contra-flexure in the arch, to compensate for the combined effects of shrinkage, creep and elastic compression of the concrete. This will be done by operating groups of "Freyssi" flat-jacks, cast into two special diaphragms in each rib. These diaphragms will each contain fifty-two groups of three flat-jacks in series, which will initially be inflated with hydraulic fluid at a pressure of 2000 lb per square inch, producing a movement of 1in in each jack. The hydraulic fluid will then be replaced with cement grout, this operation being carried out in one jack at a time.

The total jacking movement in each rib will be of the order of 6in and, since at this stage only part of the shrinkage and a negligible amount of creep will have taken place, the profile of the arch will be slightly above the final level. This will facilitate the removal of the centering.

On completion, the ribs will be made to act as one arch by means of transversely prestressed diaphragms. The working stress in the concrete arch, under the combined effects of bending and direct thrust, will not exceed 2250 lb per square inch. The strength of the concrete will be 6000 lb per square inch on works cubes tested at twenty-eight days.

The arch abutments will be of mass concrete keyed into the sandstone forming the banks of the river. Access into these abutments will be provided from which the interior of each rib will be accessible for inspection and maintenance of services.

During the construction of each rib the precast units will be supported on steel centering designed to exploit fully the repetitive nature of the work. Apart from the structure at mid span extending the full width of the bridge to be used for lateral transportation of the units the centering will consist above water level of a steel structure capable of supporting one rib only at a time. This structure will be moved successively to each of the four rib positions.

Except for a 220ft navigation span of mild steel lattice girder construction the main longitudinal beams will be 36in by 16½in universal beams in high tensile steel to B.S. 548 which are the strongest standard sections available. These have been rolled in the United Kingdom by Dorman Long and Co., Ltd., and shipped to the site. They will be used in spans varying up to 60ft, the spans having been selected to make full use of the bending strength of the beams, which will be spaced at 18ft centres. To the lower flange of these main beams will be attached lateral 8in by 6in beams in mild steel which will project on both sides of the structure to support working platforms. These lateral beams will also support longitudinal rails located between the main beams on which will run a specially equipped trolley for conveying units to their final location and for jacking them to the exact line and level required. The precast units will be supported on blocks mounted on the upper flanges of the longitudinal beams, the thickness of each block being predetermined to allow for the curvature of the arch soffit along each length of universal beam, and also for the calculated deflection of the beams under full loading.

Tubular steel columns varying from 36in to 60in in diameter will be used to support the longitudinal beams and these will be at 18ft centres at the top, increasing to 21ft centres at the base. Lateral stability will be provided by mild steel wind bracing whilst longitudinally the columns will be prevented from overturning by the longitudinal beams which will extend continuously from the arch springing.

The structure at mid span will comprise two sets of five columns extending across the width of the bridge and projecting as cantilevers on one side and supporting lateral beams at the level of the arch socket. These beams will support the ends of the adjacent longitudinal spans and will also support rails on which another specially constructed trolley will run.

Above the cantilever projection will be mounted a 50-ton winch which will lift precast units vertically from river barges, and will lower them on to the laterally moving trolley. This will then be moved to the line of the rib under construction where the unit will be picked up by the longitudinal trolley and lowered around the arch profile to its final location.

On completion of each rib, the centering, which will have been freed by the operation of the "Freyssi" jacks, will be moved in two sections, each about 500ft long, to the next rib position. This will involve the simultaneous operation of winches at each pilecap, at the crown and at the springing of the arch, to move the interconnected beams, columns and bracings on each side of the crown.

The bridge deck structure will be supported on slim prestressed concrete columns, 10ft by 2ft in section, arranged in pairs and designed to accommodate expansion and contraction by flexing and so obviate the need for roller bearings at the column heads. Over the arch the columns will be supported on the diaphragms connecting the ribs and on shore by reinforced concrete foundations carried down to the rock.

The deck will terminate in reinforced concrete box abutments, to which it will be anchored. It will also be anchored to the crown of the arch and there will be expansion joints midway between the crown and the abutments.

The deck structure will consist of eight precast prestressed concrete beams in each span set upon reinforced concrete crossheads mounted on the columns. The deck will be completed by an *in-situ* concrete slab, heavily reinforced over the junction between spans to give continuity under live loads. The deck will have sixteen spans of 100ft and a central section of 300ft supported directly on the crown of the arch.

The carriageway width will be 72ft and two footpaths, each 6ft in width, will be provided. The maximum road gradient will be 6 per cent. The deck loading used in the design was the standard loading adopted by the road department, which in general terms is rather less than the standard loading used in the U.K.

The bridge is to be constructed for the Department of Main Roads, New South Wales, who originally invited tenders for either the official design, a multi-span steel cantilevered bridge, or for other competitive designs. Reed and Mallik, Ltd., of Great Britain, in partnership with Stuart Bros. Pty., Ltd., of Sydney, submitted the lowest tender, based on a design by G. Maunsell and Partners, of London and Melbourne, and their tender was accepted.

Constructional work is about to be commenced and the bridge is expected to be completed by 1962.

Royal Institution of Naval Architects

ANNUAL SPRING MEETING

(No. III—*Continued from page* 611, *April* 8)

THE second paper read on the afternoon of Wednesday, March 23, was :

AN OCEANOGRAPHIC RESEARCH SUBMARINE OF ALUMINIUM FOR OPERATION TO 15,000ft

By EDWARD WENK, JNR., ROBERT C. DEHART, PHILIP MANDEL, and RALPH KISSINGER, JNR.

SYNOPSIS

Design Analysis of an oceanographic research submarine has been completed which indicates the feasibility of operating to depths of the order of 15,000ft for manned exploration at the very bottom of about 60 per cent of the ocean areas of the world. This performance represents a quantum jump in depth capabilities over the relatively shallow limitations of present combat submarines, and may thus lay the groundwork for future extension of depth ranges.

The paper describes the performance required for research missions, the basis for structural design featuring the use of high strength aluminium alloys in the hull, details of internal arrangements, modular concepts, power and propulsion capsule, ballast systems, manœuvring and control, buoyancy and stability, and mechanical auxiliaries. Results are summarised from initial tests of both structural and hydrodynamic models.

DISCUSSION

Mr. J. F. Starks, R.C.N.C.: I would first say how welcome are contributions to our Proceedings from the other side of the Atlantic.

One of the most interesting points made in the paper is the increase in buoyancy due to the increased density of sea water at depth. Referring to the factor of safety of 1·4, the authors mention that this figure is comparable with that of commercial aircraft. I would have thought that the life of twenty years specified for the "Aluminaut" was rather greater than that of an aircraft. I agree that the factor of 1·4 is adequate when the boat is new, but recommend reconsideration of this figure or the operating depth during the life of the craft. My forecast is that progressive reduction of operating depth will result, and that after each major refit which involves parting of the hull, an unmanned dive will be carried out.

It is pleasing that the tests for strength were made a fairly large number of times. The importance of so doing cannot be overestimated. Were the fatigue tests on material and the repeated deep dives by the model carried out in the all-round presence of sea water, and do the authors consider this to be important from the standpoint of corrosion fatigue ?

Could some additional data be given on how the bonded joints are made and cured during construction and after refits, and does the repeated application of the curing temperature affect the properties of the aluminium or cause any distortion ?

How is it proposed to check the strength of the cured joints in the craft itself ? One immediately thinks of an internal pressure. If this is contemplated, what pressure is visualised ? Further, having made these joints, how are the sections to be separated when the craft is refitted ?

Turning to the equipment described in the paper, consideration was given to an arrangement permitting jettisoning all or part of the battery if necessary. It is not surprising that the effect on stability prevented this, and I suggest that the designers consider mounting some of the cells on a platform so that they can be moved forward and aft to help trimming. It might be better to move a big weight rather than pump thousands of gallons of water.

The point is made that high-pressure air is completely eliminated from inside the boat, and yet the oxygen cylinders are inside. Is there not a good case for locating the oxygen cylinders also outside the boat ?

Mr. Wenk (in reply) : With regard to separating the sections of the hull, this would have to be done on very rare occasions, unless serious damage has occurred, in which case we would be separating both parts of the section. It can be done, but we do not expect it to be done often.

As to putting the hull together, when the bonded joint is formed the surfaces are sprayed and the two safety bonds brought together at a temperature of about 275 deg. Fah. This particular aluminium alloy loses strength at about 300 deg. and during the bonding it is necessary to limit the temperature to 275 deg. or 265 deg.

We were perturbed about fatigue in the presence of sea water, but the design is very carefully proportioned so that tension occurs nowhere, and the body is exclusively in compression. As to the suggestion to move the battery cells in order to trim the boat, it would be difficult to do that. Concerning the suggestion to locate the oxygen cylinders outside the boat, our decision may not have been wise. But what happens when there is an accident and the crew struggle to make repairs, and they want a sufficient supply of oxygen inside ?

Mr. R. H. Richards, R.C.N.C.: My first question is on hull penetrations for the very great pressures involved. How are they to be arranged, for the electric cables, and also for the steel release cables operating the lead drop-keel ?

The next question concerns the bolting arrangements, details of which are not given. It seems possible that important concentrations may occur around bolt holes, because Fig. 5 in the paper indicates that the stresses are high on the inside, in way of the frames. Also, on the question of jointing, it is presumed that extrusion of the bonding material does not occur under the very high compression at great depths. With regard to general hull strength, collapse by shell yield is stated to be 21,000ft, using a yield stress of 60,000 lb per square inch. Yet Fig. 5 shows, at 21,000ft, a mean circumferential stress midway between frames of 76,000 lb per square inch, and in Table V, summarising structural model tests, two collapses are given as failing by general instability ; it is thought that this could have been shell yield which then precipitated general instability because of the high energies involved.

Mr. Wenk (in reply) : With regard to hull penetrations, we went to extreme measures to avoid them. There are virtually no openings in the cylindrical shell, they are all in the spherical shell. This particular detail has already been worked out and tested, and has withstood the pressures with no trouble at all. It is to be checked by a further model test, as described in the paper. Also the arrangement for releasing the steel cables has been worked out.

Concerning extrusion of bonding material, tests have been made and if the material is properly bonded it does not extrude. Perhaps the position with regard to yield strength needs further elaboration. It is true that the yield strength of the material is 60,000 lb per square inch. When that material is in a bi-axial field, as in a cylinder, yield does not occur until the stresses are 14 per cent higher. As to collapse depth, the yield begins at about 19,700ft, but the collapse depth is 21,000ft.

Mr. L. J. Rydill, R.C.N.C.: When "Aluminaut" has successfully completed her test dive, her importance as a vehicle for oceanographic research will depend on features such as speed, manœuvrability and controllability. I get the impression that these have not received so thorough an investigation as that of pressure hull strength.

Our knowledge of the way in which circular cylindrical pressure hulls fail due to the local collapse of the shell plating is compounded of the results of theoretical and empirical investigations into the strength of thin shells. Is it valid to apply these results to the very thick shell of "Aluminaut" ? The *ad hoc* experiments on models of her hull will, of course, demonstrate that no gross errors are likely to arise from this extrapolation, but it appears possible that the authors' assumption of complete fixity at the ends of each bay—and the associated deduction that the elastic stresses in the shell never become tensile—may become invalid once yield is initiated on the inner surface of the shell.

Bearing in mind that "Aluminaut" is bounded at its ends by two hemispherical domes which are far less stiff radially than the transverse bulkheads in conventional submarines, what is her compartment length ? Again, is it valid to apply theories developed for thin shells to the overall collapse of the thick pressure hull of "Aluminaut" ?

The authors have generally avoided stress concentrations around pressure hull penetrations such as hatches, but since they have included two viewing ports in the forward dome it is relevant to ask what stress concentrations occur around these, and how their effect on the fatigue strength of the hull is to be evaluated.

Although a major advance on the performance of the bathyscaphe type of vessel, "Aluminaut's" speed range of 0 to just under 5 knots is likely to be an important limitation on her usefulness for oceanographic research. I am surprised that the authors have not aimed at better streamlining with a view to improving both speed and endurance.

I consider that the after hydroplanes will be of relatively little use for depth control and depth changing for it is known that forward hydroplanes are essential for satisfactory submerged control at low speeds, because the after hydroplanes are either ineffective or actually give an opposite effect on the boat to that desired. Recently we have been able to explain this, using the concept of the effective centre of pressure—the point defined by the ratio of the total moment (hydrostatic plus hydrodynamic) on the submarine due to change of trim to the associated total force (hydrodynamic only). At relatively high speeds this point is close to the hydrodynamic centre of pressure (defined by the ratio of the hydrodynamic moment to the hydrodynamic force and usually just forward of amidships), but as speed is reduced it moves aft, due to the

increasing importance of the hydrostatic moment in opposing change of trim. At some speed, known as the critical speed, the effective centre of pressure will coincide with the position of the after hydroplanes, and operation of these hydroplanes will then cause change of trim, but no change of depth. Below this critical speed the effective centre of pressure is abaft the after hydroplanes and their operation will cause change of depth in the "wrong" direction. For speeds in the vicinity of the critical speed depth control and changing will be sluggish.

I have estimated that the critical speed in "Aluminaut" will be of the order of 2½ knots, and it appears inescapable that she will respond sluggishly to the use of after hydroplanes over the whole of the speed range. Clearly there is a need for comprehensive model basin experiments into the hydrodynamic features of "Aluminaut."

The ideal solution would be to replace the after hydroplanes by forward hydroplanes sited as far forward as practicable. Additionally, to improve depth changing, the internal trim tanks could be increased in size to allow, say, up to about 500 lb of water to be moved as necessary to put a trim angle on the boat.

I am not convinced that a fixed pitch vertical propeller will, in practice, give the vernier control of depth envisaged by the authors. For this purpose a variable pitch propeller would be better, the direction of rotation of which could be kept constant and whose thrust could be varied and reversed as required by changing pitch.

Mr. Wenk (in reply) : Concerning further hydrodynamic tests, this project is not a matter for the U.S. Navy, but a commercial undertaking which spends many dollars every time this work is done. I think they deserve real credit for indicating what one should look for in oceanographic research. But that is the reason why we have not been able to run all the hydrodynamic tests we should have liked. When we studied such tests with a view to making, possibly, some changes in design, we were convinced that a full-scale test would be no more expensive.

The vertical propeller is a simple device mainly for maintaining depth.

As to having hydroplanes at the bow in addition to or instead of those at the stern, this was widely discussed with submarine operators, and there was agreement that the same results could be achieved with hydroplanes at the stern as at the bow.

Mr. M. F. Gunning : This concept is an enormous advance on the bathyscaphe. One reads of difficulties in handling the petrol, of precautions that have to be taken, the trimming difficulties caused by the compression of the petrol at great depths, by variations in the temperature of the sea water, and the freezing that occurs when the petrol is decompressed on the way back to the surface. The "Aluminaut" concept is more sound, quite apart from some more directly apparent advantages, such as greater speed, radius of action, habitability, &c.

All this is made possible by the use of aluminium. The designer of conventional submarines is allergic to the use of this material ; he deals with thin shells under compression, liable to collapse, and he requires a material with a high Young's Modulus ; also he is worried by loss of buoyancy at what he calls great depths. All this takes on a different aspect at the depths we are dealing with here. The thickness of the shell is now so great that collapse is practically out of the question ; loss of buoyancy is in a way a constant factor, independent of the diving depth. On the other hand, the gain in buoyancy due to the compression of the water continues to increase with the depth and, unexpectedly, at a certain stage turns the loss of buoyancy into gain.

I am impressed by the importance of seaworthiness at the surface. The ship has to be towed into the open sea and boarded there ; after the dive, the crew have to be taken off, and the ship towed back to base. A reserve buoyancy of 2 per cent, instead of the usual 20 per cent, seems very low indeed. Also the dome or hatch is very near the surface, so that perhaps some kind of conning tower or "sail" should be fitted. The outside ballast tanks could be increased in size for little extra weight, say, less than 20 per cent of the existing weight margin. Incidentally, this would allow the sections of the craft to be bolted together, a construction which, from the technical point of view, may not be superior to the bonded joint proposed by the authors, but might have a psychological appeal to the crew. Incidentally, how would the bonded joints behave under shock ? Under those circumstances there can be no guarantee that no tensile stresses will occur.

One wonders why the high-pressure bilge pump is not further employed as trimming pump in conjunction with a very small auxiliary ballast tank. Even a capacity of a few hundred pounds would greatly facilitate the operation of the vessel.

Why have no ordinary submerged model tests been made to assess resistance and manœuvrability ; what formulæ were used to determine the stresses and deformation of the hull, and what kind of stuffing-box is used to take the wire supporting the emergency ballast through the pressure hull ?

Mr. Brooks : I will restrict my remarks to the subject of manœuvring on the sea bed.

During the last war I had experience with a vessel of a similar type, which we were to operate on the sea bed. On first attempting it, the vessel went into a fissure on the sea bed and came up at an acute angle. We modified the vehicle with four hydroplanes, as now suggested, and the craft was able to proceed over the sea bed, following the contours and rocks more easily. The incorporation of an echo sounder which not only transmitted downwards but also forwards was of great assistance.

Mr. Wenk (in reply) : Perhaps I should clarify the matter of assembling the boat. The aluminium sections will be joined both by bolting and bonding. In any event, the philosophy we have adopted follows that reasoning. In the first instance we had to get rid of the idea that the joint would be as strong as the parent metal ; we had to consider joints made other than by welding. We realise that in this design all the elements will be in compression ; the models have all the elements put together with grease ; they are simply held together until the pressure is applied, and once it is applied they are stabilised by the pressure. I quite agree that it would be wrong to depend on the bonding alone.

It is true that we have not much reserve buoyancy. The question of providing some kind of additional conning tower has been considered to preserve the dryness of the crew when getting on and off the boat. We have not looked at the matter of increasing the size of the outside ballast tanks. But perhaps we shall improve the service performance.

The use of bow hydroplanes may eventually develop. Maybe, with the boat getting into construction, others will make some tests.

The Spring meeting was resumed on Thursday morning, March 24, with Mr. James Turnbull in the chair, and the presentation of :

METHANE TRANSPORTATION BY SEA

By E. C. B. Corlett, M.A., Ph.D., and J. F. Leathard, B.Sc., Ph.D.

Synopsis

The paper records the physical properties of natural gases and gives flow diagrams of three methods of liquefaction. General considerations of ship design are considered, touching upon questions of boil off, structure, piping, loading and discharging, while another section deals with safety related to ship structure, tank structure, free surface and retarded boiling. Particular attention is paid to tank design such as shape and suitable constructional materials, followed by notes upon insulation. The paper concludes with a design study of a 10,000-ton methane tanker.

Discussion

Mr. L. W. Jefferson, B.Eng.: The major problem in producing a ship of this kind is the design, arrangement and construction of the internal tanks to carry the methane, and great pains have been taken to derive scantlings for the tanks to withstand the complex system of loading, and in the particulars given the authors estimate a total weight of 1400 tons for the cylindrical aluminium tanks in a ship to carry 10,000 tons of methane. I have compared this weight figure with others derived in another study, and there is close agreement.

Although a working or design stress of 3½ tons per square inch is the basis of the NP 5/6 aluminium alloy, in the one case I have mentioned the dynamic loads have been taken into account in calculating the stresses, whereas the authors of this paper state that the acceleration loads can be neglected ; presumably they are assumed to be allowed for by the factor of safety. It would be interesting if the authors would comment on the acceleration loads.

It is worth mentioning that the small tank illustrated in Fig. 6 in the paper is by no means comparable in scantlings with the large tanks, of up to about 70ft diameter, which would be required for the 10,000-ton methane tanker which they illustrate. The weight of those large tanks would be perhaps 230 tons in aluminium and anything up to 480 tons in nickel steel. The prospect of lifting such large tanks out of a ship for inspection, especially taking into account the dismantling of the adjoining structure, appals me, and it is hoped that the possible alternative of removing part of the insulation for this necessary inspection would be acceptable.

In discussing the shapes of tanks the authors mention the advantage in capacity of the rectangular tank, and explain that that could be largely countered by using a multiplicity of small tanks, probably cylindrical. A further possible advantage of the rectangular shape tank is that it would lend itself to prefabrication by more or less conventional methods ; and as the tanks would probably have to be built on the berth at the same time as the structure of the ship, this may be of some importance. Against the rectangular tank is its greater surface area per unit volume. On the grounds of stability, an estimate seems to show that the difference between the rectangular and circular tank arrangements would not be sufficiently great to be critical.

One presumes that the choice of material as between aluminium alloy and an austenitic or nickel steel must be based largely on cost, and ease of fabrication. Although the characteristics of aluminium, which seems to be the material favoured for this application at the moment, are fairly well known, it

is rather difficult to obtain accurate equivalent information about some of the nickel steels now recommended.

Figures are given in Table IV of the paper for typical properties of aluminium plate containing 5 per cent magnesium. It may be worth mentioning that these figures refer to plate of ¼in thickness. The thicknesses to be used in this case would be up to 1–1½in, and the mechanical properties for the material in such thicknesses would be something like 19 tons per square inch ultimate tensile stress, and 9–10 tons per square inch for proof stress, which are lower than the figures given by the authors, and the elongation would be about 20 per cent higher than they mention.

Mr. Knud E. Hansen : Of greatest interest for a successful design is the right purpose. It seems to me that the goal is to transport the gas at the lowest possible price, consistent with safety. This means that, taking account of running costs, the design giving the smallest cost of ship per unit of gas carried must be the most advantageous.

The author's aim, in design, has been that the space containing the tanks in a normal hull form should be as large as possible to permit of maximum tank capacity. I would ask if unorthodox ship forms have been considered. From investigations of different hull designs we have found that one with spherical tanks projecting well above the deck level in a special hull form gives the best solution for gas transportation. The space utilisation efficiency in the midship section with cylindrical tanks, including make-up tanks, is given in the paper as 0·48. In our design with spherical tanks this value is about 0·80, no make-up tanks being required.

Another factor in the evaluation of the different designs is the number of tanks. When using spherical tanks the number required for any ship can be taken as five ; thus the number of valves, pumps, pipelines, &c., can be kept to a minimum.

We have not found that spherical tanks, whilst offering the most symmetrical structural arrangement, incur excessive practical design disadvantages. The design and construction is relatively simple and do not necessitate double-skinned hulls to obtain adequate transverse section modulus, as in the cylindrical tank design.

The special hull form we apply in the design for spherical tanks has a relatively large beam at the waterline. This form has many advantages. For example, it gives adequate stability in all conditions, even with spherical tanks projecting nearly half their diameter above the upper deck level. Also the weight of the liquid under any condition of filling the spherical tanks is suspended in the centre of the tanks, so that there is no risk from slack tanks due to boiling-off.

In respect of the structural arrangement, by reason of the smaller breadth of the bottom flange the unbalanced nature of the midship section for a normal hull form is avoided. In the space between the gas tanks, U-shaped tanks are fitted, giving adequate transverse strength combined with a considerable capacity for oil and water, so that nearly all the space is utilised.

The supports for the spherical tanks can be arranged along the equator line, corresponding to a design developed in connection with Professor Hannemann, eliminating any bending forces on the shells. The support terminates in a continuous ring, supported by a fixed ring, with a flexible insulating material between the two rings. No heat bridges are formed, so that the heat transfer is minimised. The support is thus floating, for we have found it desirable to provide some flexibility to take up the ship's deflections, especially for the tank forward, also to take up acceleration forces from slamming which may produce a heavy boiling of the liquid. Values as high as 6 *g* for the slamming have been measured ; but a value at least above 1 *g* may be expected.

As mentioned in the paper, the value for surface area per unit volume is 23 per cent lower for spherical tanks than for cylindrical tanks and, as no stiffeners are required, the weight and cost of the spherical tanks must be smaller than for cylindrical tanks. With regard to insulation, it seems that the ideal solution must be to place insulating material inside the tanks. In the future I think it may be possible to develop a fully reliable insulating material, but up to now I have not found a fully tested insulating material which fulfils the requirements. With outside insulation the tank cannot be inspected ; and outside insulation on the cold tank will accumulate moisture in the insulation if it is not absolutely tight. For these reasons we prefer to place the insulation inside the ship's structure, where the insulation will dry out and no difficulties will arise from heat variation. If it is not gas-tight the insulation must be covered by a layer of aluminium sheets or other material, forming, in the case of failure of the tank, a second barrier.

It is interesting to compare the specific design study in the paper with a design of a ship carrying spherical tanks. The particulars are :

	Cylindrical tanks	Spherical tanks
Length	600ft	570ft
Breadth moulded	78ft	93ft max.
Depth moulded	58ft	52ft
Speed	15½ knots	17 knots
S.h.p.	12,000 b.h.p. twin screw (turbine)	13,000 b.h.p. single screw

The speed given in the paper seems to me rather low for this expensive ship. Even with the higher speed for the spherical tank design and the methane installation, including refrigeration of the boiled-off gas, the weight is considerably reduced and the construction is far less complicated. The steel hull weight given for the ship with cylindrical tanks seems to be considerably lower than our calculations indicate. The hull form from the point of view of propulsion is favourable, as shown by model tests, and does not increase the building price.

Mr. G. M. Boyd : I am surprised by the small space devoted to the selection of materials for this kind of work by the authors. We must remember that this is an adventure in engineering, the carrying of enormous quantities of liquids at temperatures as low as −160 deg. Cent. In the information about materials little attention is paid to their behaviour at these low temperatures. There are results of the keyhole tests in relation to the A.S.T.M. A–353 nickel steel. But the keyhole has a very blunt notch and the test gives a very poor indication of behaviour in service. Similarly, for the aluminium alloy, we have the Izod values at room temperature. In embarking on projects of this kind we want to go more deeply into the properties of materials.

In sub-section 4.3(*b*) of the paper, it is stated : "If the tank is not full, motion of the liquid inside the tank will produce dynamic forces at the free surface." There is some evidence that the great mass of the liquid in the centre of a tank remains practically stationary and there is turbulence and movement at the periphery.

Lieut.-Commander (E) M. B. F. Ranken, R.N. : I hope it will be worth mentioning the major problem of supplying such a vessel with the large quantities of cargo. It requires about 6000 h.p. to produce 100 tons of methane per day and from figures in the paper one would expect about one voyage per month. An output of 350 tons per day would require a plant of about 18,000 h.p. to 20,000 h.p. I appreciate that the cost of producing the methane is well within bounds, but the physical size of the plant worked out on that basis is very formidable, even to supply one ship.

Again, to deal with liquefaction requires about 2000 h.p. on board the ship. I am rather doubtful about covering the cost of about 40 tons extra deadweight represented by the size of plant required, in view of the very wide temperature ranges. But it seems that there is to some extent a way around that problem. The insulation on the side of the ship has been mentioned. Why not also reduce the temperature range by about one-third by refrigerating the ship itself ? The temperature range will be smaller and therefore the plant should be cheaper. I would have liked to have heard about the tests of the insulation, because surely that is the crux of the thing. A lot of the materials mentioned are liable to be inflammable. If there is a fire on board there will be trouble from the classification people.

Dr. W. Muckle : I would put in a plea for rectangular tanks. In this type of ship the stowed weight is so high and it seems to need so many cubic feet per ton that I would think that to get the maximum cubic capacity in the tanks is a most essential feature.

In connection with the insulation of the tanks, it would seem that the internal insulation system would have some advantages. With internal insulation, presumably, the structure of the tank is not reduced to a very low temperature. That would give benefit in respect of the thermal expansion effects and, from the point of view of the type of construction material used, to give good properties at low temperatures, which is essential.

Also there is the question of the choice of materials as between the steels which are now quite successful at low temperatures, and aluminium. I think it is generally recognised that aluminium does not show the notch sensitivity properties which are generally associated with ordinary mild steel and therefore it seems to be suitable for this work, although the price is marginal between those of mild steel and the special steels.

In connection with the forces generated and which are listed in the study of this problem, the authors are quite right in neglecting any dynamic forces which, in the ship, are quite small, and when the ship is heeled the major ones to be dealt with result from the dead load.

(To be continued)

Telephony/Teleprinter Converter

WHERE additional telephony channels are not practicable in a radiotelephone link, increased capacity may be obtained by the use of teleprinters. A converter unit enabling an ordinary radiotelephone equipment to be used for teleprinter working has been introduced by Redifon, Ltd., Broomhill Road, London, S.W.18. This all-transistor keyer/converter, GK.189, consists of independent keyer and converter sub-units mounted with their own power unit on a common chassis, which can be fitted into a cabinet or a standard 19in rack. The keyer transforms impulses from a teleprinter output into two tones conforming to standard frequency shifts, suitable for line or radio transmission. The converter transforms incoming two-tones into direct current for operation of a teleprinter. Keyer and converter operate independently and, when required, simultaneously. The equipment may be worked from a.c. mains or from 12V or 24V d.c. supplies.

Electrical Engineers Exhibition

No. III—(*Concluded from page* 601, *April* 8)

THE ninth Electrical Engineers (A.S.E.E.) exhibition was held at Earls Court last week. Some of the new exhibits are described here.

Brush Electrical Engineering Company, Ltd.

Static equipment for automatic voltage control by the Brush "Rectifex" system was shown by Brush Electrical Engineering Company, Ltd. (a member of the Hawker Siddeley Group of Companies), Loughborough, Leicestershire. This particular "Rectifex" equipment provides fully-automatic static excitation for a 2700kW, unity power factor, 6·6kV, 50 c/s alternator, which is being made for the Corporation of Liverpool.

It is the largest static excitation equipment yet built by the company, and it illustrates an important potential application of transistor and magnetic amplifier techniques to the control of large electrical machines.

At the other end of the scale there was an exhibit demonstrating the possibilities of applying controlled silicon rectifiers to the speed control of (in this instance) a 1 h.p. d.c. motor, and of using punched tape to provide overall programming of such a control system. In this scheme speed control is effected by armature voltage variation through the medium of controlled silicon rectifiers, which are duplicated in the reverse direction for regenerative braking; these reverse rectifiers can also be used for reverse operation of the motor if required. Accelerating or braking armature currents are automatically limited to the desired level by a current limit circuit. The machine field is supplied by an auxiliary rectifier.

The armature voltage control takes the form of a closed-loop servomechanism in which the speed signal from a tachogenerator is compared with a reference, giving rise to an error signal which feeds a transistorised control amplifier. A linear phase shift circuit controlled by the transistor amplifier supplies four pulse circuits which fire the controlled silicon rectifiers in a bi-phase rectifier-inverter power circuit. The (magnetic) amplifier and pulse circuits are mounted on plug-in boards so that a faulty board can be immediately replaced by a spare in the unlikely event of a failure.

Brief Specification of Silicon Rectifier Speed Control System

Speed range	100 : 1 by armature control.
Load torque	Constant throughout speed range.
Speed regulation	Less than 1 per cent of top speed.
Current limit	Adjustable between 75 per cent and 150 per cent of full load.
Braking	Regenerative deceleration at current limit setting by inversion.
Overhauling loads	Controlled within regulation of 1 per cent of top speed.
Maximum horsepower ...	Dependent on available controlled silicon rectifiers (at present about 5 h.p.).
Reversible drives	Optional.

The speed can be controlled in two ways: (1) manually, via a speed setting potentiometer; (2) automatically by a programmed input reference voltage signal. The latter method lends itself ideally to programme control by paper tape input, the tape reading unit selecting the required reference voltage according to the information punched on the tape.

A number of special exhibits on this stand included a submersible motor designed to show the possibilities of using water for lubricating the bearings of a motor with winding insulation capable of withstanding immersion in water. The use of class C insulation, suitable for temperatures of about 600 deg. Cent., was demonstrated for high-temperature motors, with potential applications in nuclear power and the steel industry.

Westinghouse Brake and Signal Company, Ltd.

Applications of "Trinistors" and silicon power transistors were prominent in a display shown by Westinghouse Brake and Signal Company, Ltd., 82, York Way, King's Cross, London, N.1. "Trinistors" are Westinghouse silicon controlled rectifiers capable of controlling several kilowatts of power while using only a few milliwatts of control power. Some of the applications demonstrated are mentioned below.

In the 13kVA a.c. regulator two "trinistors" are connected in inverse parallel between the a.c. supply and the load, and the root mean square output voltage is varied by controlling the proportion of each half cycle for which the "Trinistors" conduct. In this exhibit the load consisted of a number of tungsten lamps with a total maximum consumption of 10kW, built into an illuminated sign. The control unit has provision for the power fed to this sign to be varied either manually or automatically, and in addition incorporates an automatic current limiting device, which in conjunction with fuses affords protection against overloads.

A 5kW controllable rectifier consists of two "Trinistors" with two silicon junction diodes forming a single-phase bridge rectifier, the d.c. output of which is varied by controlling the proportion of each input half cycle for which the "Trinistors" conduct.

The regulator that was shown is rated, in an ambient temperature of 30 deg. Cent., at an output current of 25A at up to 200V, and was demonstrated controlling the armature voltage of a 4·8 h.p. motor.

Alternative facilities are provided for either constant potential operation or manual control of the output voltage from zero to maximum, and in both cases the control unit in addition incorporates a current limiting device.

A 3 h.p. motor starter was shown, consisting of two "Trinistors" connected in inverse parallel between the a.c. supply and the motor, to function as an on-off switch. Suitable control circuits keep the switch "on" after the "start" button is released and provide fully automatic overload protection. The exhibit demonstrated the starting of a 3 h.p. motor drawing 15A at full load and 80A at starting, and shows the effect of a simulated motor overload by connecting a low value of resistance across the motor.

A 1kW single-phase inverter embodying two "Trinistors" to generate 1kW of a.c. power at 240V, 1000 c/s with a nominal 24V, d.c. input, was shown supplying a bank of twelve 80W fluorescent tubes. The full-load efficiency of the inverter is 85 per cent, and the load regulation is −5 per cent from open-circuit to full load.

Similarly, in a typical 5kW three-phase inverter the d.c. input was switched cyclically by three "Trinistors" between the outer terminals of a star-connected primary winding on a three-phase transformer, the switching being effected by a three-phase pulse generator in conjunction with commutating capacitors. The unit shown delivered 5kVA at 110V, 400 c/s with a d.c. supply of 110V, at an efficiency of 95 per cent.

Brookhirst Igranic, Ltd.

A new range of a.c. motor starters which is being introduced to cover most methods of starting and to include reversing control, was shown by Brookhirst Igranic, Ltd., Bedford. These starters incorporate block contactors and either magnetic or thermal overload protection, all the equipment being arranged for easy accessibility. Initially the range will be up to 30 h.p. but this will be extended and versions for marine service are being introduced.

Another new starter seen at this exhibition is an air-break direct-on-line contactor starter for 3·3kV (Fig. 23). It is based on the

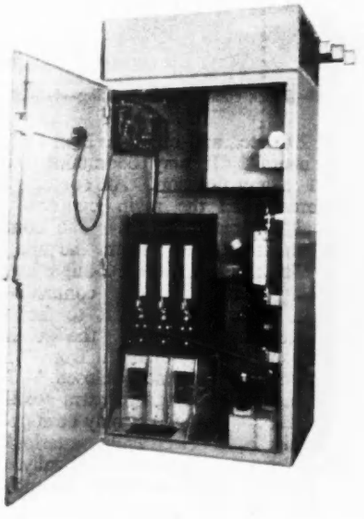


Fig. 23—3·3kV direct-on-line starter—Brookhirst Igranic

B.H.I. high-tension contactor No. 7423, A.S.T.A. tested to B.S. 775, category A4, mechanical duty class II. The A.S.T.A. test involved making and breaking the following currents: fifty times at ten-second intervals at 0·25 p.f., 3·3kV, 600A, 900A, and 1200A. Tests were carried out in succession on the same contactor. Through fault capacity tests with 150A, 3·3kV, fuses are covered by A.S.T.A. certificate at a prospective fault level of 150MVA. The main three-phase busbars are A.S.T.A. certified for 150MVA for three seconds.

The "BI-Stat" static switching system was represented on the B.H.I. stand by a working model of an installation illustrating the inspection, counting and segregation of workpieces on a multiple conveyor system. Typically, an arm at the end of the conveyor feeds each workpiece to one of two machine tools. If both machines are loaded, the workpiece is recirculated. The arm thus chooses, on the approach of each blank, one of four possible steps from any of three possible positions. The "BI-Stat" logic unit receives information about the positions of blanks and arm from magnetic-amplifier proximity switches, sorts them and, through "trigger" and amplifier stages, drives the arm up or down as needed.

The model showed the small panel space required by these encapsulated, static, contactless units, which need no maintenance.

G.W.B. Furnaces, Ltd.

The exhibits shown by G.W.B. Furnaces, Ltd., Dudley, Worcester, included a new B.20 block contactor (Fig. 24) which is

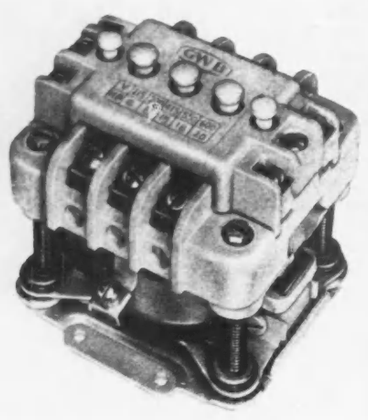


Fig. 24—Block contactor, 20A rating—G.W.B.

rated at 20A a.c., and measures 3¼in by 3¼in by 3in overall. It may be mounted and operated in any position. All contacts are double-break and the main contacts are of special sintered material. The contact mechanism is separate from the magnet assembly, to give complete self-alignment of all moving parts. Moving contacts are captive in the contact carriers to facilitate removal and maintenance; the auxiliary contacts can be easily changed from "normally open" to "normally closed." Provision is made for fitting two extra auxiliary contacts and two contactors may be supplied mechanically and electrically interlocked, mounted either horizontally or vertically.

When the solenoid is energised, the moving magnet is attracted to the fixed magnet. The contact tappets ride on the moving magnet and, in turn, operate the contacts. When the solenoid is de-energised, the four main pillar springs return the moving magnet to its original position which simultaneously returns the contacts to their normal position.

Harmer and Simmons, Ltd.

A new approach to automatic battery charging—in which the process is controlled by the gassing of the battery—is being developed by Harmer and Simmons, Ltd., Roebuck Road, Hainault, Essex. It is based on the "Catylator" (The Engineer, February 6, page 359), a small self-contained unit which is fitted by a screwed adaptor into the filler aperture of the battery and contains a catalyst (palladium): the gases generated in the battery are combined by this catalyst to form steam which condenses on the inner surface of the "Catylator" and drips back into the battery, thus preventing corrosive emissions and loss of water by gassing. Energy is generated by the recombination of the hydrogen and oxygen and appears as heat. This energy is a direct measure of the rate of recombination. By fitting a temperature sensitive element in contact with the "Catylator" it is therefore possible to use the gassing to control the output of a battery charger and the company is developing a system of control based on this principle.

It is known as the "Cyclocat" and it works as follows. At the start of a charging cycle below the gassing voltage the charging current is limited by the battery characteristics and the designed maximum output from the charger; this maximum is fixed by economic considerations and the time available to complete the charge. When gassing begins the temperature rise in the "Catylator" (which takes account of the battery electrolyte temperature as well as the recombination energy) assumes control of the charging current and regulates it until the end of the charge. At that point most of the charging current will be spent in electrolysing water and the energy will appear as heat resulting from recombination in the "Catylator." By suitable design of the "Catylator" and temperature sensing element, it is proposed to predetermine the final charging rate and to limit the maximum temperature rise under any ambient or charge conditions. At that point the charge can be ended by a current-sensitive relay.

Each cell is fitted with a "Catylator," and one or more of the "Catylators" is fitted with a thermistor, the resistance of which varies inversely with temperature. The thermistor is connected in series with the control input terminals of a "Cycloc" charger, across a d.c. reference supply. The output from the charger output voltage then varies inversely with the control current and the "Catylator" temperature.

In the first practical series of tests of the "Cyclocat" method of charging, a traction battery was recharged at an ambient temperature of 0 deg. Cent., the voltage being maintained automatically at about 2·6V per cell during the charge. Then the battery was given another recharge in an ambient temperature of about 100 deg. Fah., without any other change in the conditions, and the voltage was maintained at about 2·3V per cell. In both tests after an initial limited constant-current state had been passed the characteristic of the charging current curve was similar to that given by the "ampere-hour" relationship but with automatic adjustment for battery temperature.

Another demonstration that was given by Harmer and Simmons, Ltd., showed a system that has reached the stage of commercial development. It is known as the "Cycloboost" and its function is to maintain a battery on load, in a fully charged state without allowing it to be undercharged or over-charged, without significantly raising its terminal voltage, without disconnecting it from the load and without switching between it and the load. Briefly the equipment consists of (i) a "Cycloc" automatic float charger, with a battery floated across it, which normally carries the load and keeps the battery charged, and (ii) an automatic switching system which connects a second "Cycloc" charger to each cell of the battery in turn, in a repetitive cycle. This second charger replaces battery capacity lost through peaks of high demand, and keeps all the cells fully charged and equalised. The increase in voltage (above the open-circuit value) needed to charge any one cell is small relatively to the voltage of the whole battery. By charging the cells singly, in sequence the increase in output voltage, in batteries of about 50V and above, is less than 1 per cent. Used in this way "Cycloc" chargers can maintain a fully-smoothed output with the voltage controlled to within ±1 per cent over the whole range from no-load to full-load, regardless of mains variations of 10 per cent in voltage and 2½ per cent in frequency; greater tolerance to mains variations can be incorporated if required.

A rotary switch driven by a slow-speed motor controlled by a current relay connects the second "Cycloc" charger to each cell in turn. This switch has gold-plated contacts to ensure minimum resistance. In operation, the first, or float, charger, normally carries the load and maintains the battery charge as a whole but, because of its smoothing circuit it cannot replace capacity lost by brief peaks of high current demand. Such losses are replaced by the cell charger which has the normal "Cycloc" characteristic, that the charging current falls as cell voltage rises. Thus when this charger is switched on to a cell standing at open-circuit voltage there is a current surge which opens a control relay and stops the motor driving the rotary switch. Accordingly the charger stays connected to the same cell until its voltage rises to the fully charged value. Then the charging current falls enough to operate the control relay, start the motor and move the switch to the next cell, where the charging process is repeated.

Crompton Parkinson, Ltd.

Specimens from a new series of totally-enclosed fan-cooled a.c. motors with class-E insulation, and complying with B.S.2613 were shown by Crompton Parkinson, Ltd., Aldwych, London, W.C.2. These motors have fixing dimensions in accordance with N.E.M.A. specification and I.E.C. recommendations. They are available in sizes up to 50 h.p. with temperature rise of 65 deg. Cent.; up to 5 h.p. the external longitudinal cooling fins characteristic of the larger motors are dispensed with.

Two new ranges of fractional horsepower motors were also shown. The first (T40 series) covers ratings from $^{1}/_{40}$ h.p. to $\frac{1}{8}$ h.p., either totally-enclosed or drip-proof and complies generally with N.E.M.A.-48 dimensions. The second (T50 series) covers rating from $\frac{1}{8}$ h.p. to $\frac{1}{2}$ h.p., in drip-proof, totally-enclosed or totally-enclosed fan-cooled enclosures. Both series are made to B.S.170 for a temperature rise not exceeding 50 deg. Cent., and are specially designed for quiet running, oil-felt sleeve bearings being fitted as standard.

A new range of moulded current transformers was also shown. They are wound current transformers with primary and secondary coils set concentrically on one limb of the core. The windings are moulded into a solid epoxy resin loaded with silica sand and other constituents and poured in a vacuum. The resin is combined with a hardener and the whole moulding is oven-cured. As well as enclosing the windings, the moulding is brought out to form strong supports for the primary terminals. The resin acquires a high-gloss surface finish in manufacture which, with the moulding's smooth contours, is highly resistant to dust accumulation and to corrosive atmospheres. The nominal rating in air of the CD5 unit is 11kV. It has a one-minute withstand level of 45kV and an impulse withstand level of 75kV. Standard primary current ratings are from 10A to 300A. Overcurrent ratings are up to 320 times normal for half-second up to 48,000A. Tests have shown that ultimate breakdown occurs by external flashover along the surface of the moulding and not by puncture of the insulation.

Brunt Variable Speed Motors, Ltd.

The plaque awarded by the exhibition organisers for the best industrial exhibit, was presented to Brunt Variable Speed Motors, Ltd., Chadderton, Oldham, Lancs. It may be recalled that in 1958 the Brunt variable-speed motor was awarded gold medal at Brussels and the premier award at the Paris exhibition.

The Brunt variable-speed motor consists of two single-phase repulsion motors with their armatures mounted in tandem on the same shaft and in the same frame. Both armatures are electrically independent, and

have separate commutators, and short circuiting brush assemblies. Each armature has separate field windings which can be excited from single-phase, two-phase or three-phase supplies. Speed control and reversal of rotation are effected by rotating both sets of brushes relatively to the field windings in the stator. This movement of the brushgear can be done manually by means of a handwheel or through a simple servo system with electronic control. There is no direct electrical connection between the mains supply and the armature.

The armatures are of closed-slot construction and the shaft runs in ball and roller bearings. The two sets of brushgear are mounted, one at each end of the motor, on a spur wheel with a pinion drive operated by a single shaft and handwheel. A cooling fan is fitted on the main shaft between the two armatures. The connections for the field windings are brought out to a terminal box integral with the casing, and a simple system of links enables the connections to be made suitable for single-phase, two-phase or three-phase supplies.

Continuously variable speeds from 0 to 6000 r.p.m. can be obtained, with the ratings of 2 h.p., 5 h.p., and 8 h.p. at present available, and larger sizes are being developed.

Lancashire Dynamo Electronic Products, Ltd.

New resistance welding controls, series "CWR1," mounted in a small sheet-steel floor-mounted cubicle, were shown by Lancashire Dynamo Electronic Products, Ltd., Rugely, Staffs. A variety of alternative control characteristics can be obtained from the various interchangeable sub-units that are available. They include synchronous and non-synchronous timers for spot, seam and pulsation welding; and automatic r.m.s. current regulation and synchronous and non-synchronous variable slope controls. The range of non-synchronous timers is covered by nine different models, each of which can be used in conjunction with the automatic current regulator. The basic time ranges are from 0·1 to ten seconds. Synchronous timing controls are based on ranges of one to forty-nine cycles in one-cycle steps. All models have a heat control range of 30 : 1.

The cubicle occupies a floor space of 2 square feet, the removable side panel (Fig. 25) and the withdrawable sub-unit assemblies giving easy accessibility. Replaceable printed-circuit plug-in sub-units simplify maintenance. The ignitron contactor, its auxiliary equipment and the wiring loom are common to all models.

Other new developments exhibited by this company included one-way shear register and edge register control equipments.

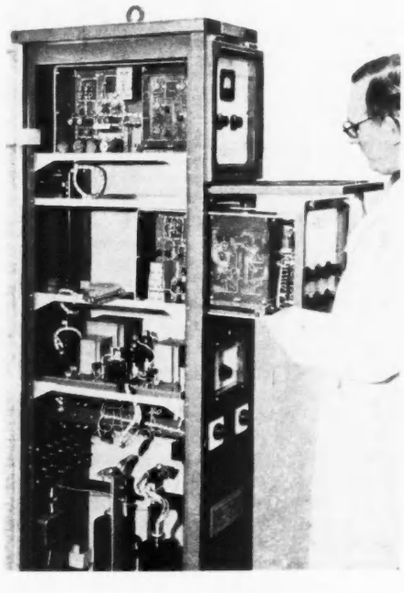


Fig. 25—"CRW1" welding control equipment—Lancashire Dynamo

Everett Edgcumbe and Co., Ltd.

A live-line indicator known as "Metrac," was shown by Everett Edgcumbe and Co., Ltd., Colindeep Lane, London, N.W.9. This company makes the indicator under licence, the development work having been done in the research laboratories of the Central Electricity Generating Board.

"Metrac" indicators are designed to comply with the safety rules of British electricity supply authorities, which require that before any high-voltage apparatus may be worked upon, it shall be completely isolated at all points of supply and, where practicable, be checked by means of an approved voltage indicator to verify that the circuit is not "live." Preferably, the type of indicator used should not require contact with the high-voltage source. Two main types of "Metrac" indicators which comply with this requirement have been developed and approved by the Central Electricity Generating Board for use on their systems. One is specifically for use on overhead power lines and the other for use at the spouts of draw-out or drop-down metal-clad switchgear and in both an identical indication is given, namely, either that the electrical apparatus is safe to earth or that it is alive (Fig. 26). The "Metrac" is a compact instrument weighing less than 2 lb and capable of being held in and operated with one hand.

The approval given by the Central Electricity Generating Board applies initially to those ranges of voltage with which they are primarily concerned, namely, 33kV to 275kV for overhead line types, and 22kV to 66kV tor metal-clad switchgear. "Metrac" indicators for use on both lower and higher voltages are available, the specific range being clearly marked on individual instruments.

Fig. 26—"Metrac" live-line indicator—Everett Edgcumbe

"Metrac" operates by detecting the electrostatic field which is set up due to a conductor being energised by an alternating voltage, and the indication given is independent of current flow in that conductor. The indicator derives its supply from self-contained h.t. and l.t. batteries; it is press-button operated and the drain on the batteries is limited to the period during which the button is depressed. Detection is by means of an electrode which, in overhead line models, is within the instrument casing (Fig. 26) and in switchgear and other models is projected to the outside of the casing.

The sensitivity of the "Metrac" is such as to ensure unambiguous readings and in the case of a double-circuit overhead line it will distinguish between the two circuits when one is completely isolated and the other is connected to the system and "live." The indicating pointer moves over two distinct areas of the scale plate, one area being coloured red and marked "Danger Live," and the other being coloured green and marked "Safe to Earth." The scale plate is illuminated so that the indication is clearly visible under all conditions of lighting.

On overhead conductors the indicator is brought to within a safe working distance of the conductors.

In Great Britain, the safety rules require these clearances to be not less than 8ft 6in at 11kV and 15ft at 275kV.

When used on high-voltage metal-clad switchgear, the indicator is offered up to the open mouth of the spouts to obtain an indication of the "live" or "dead" state of the contacts within. A shield prevents the indicator from entering the spout.

J. A. Crabtree and Co., Ltd.

Miniature circuit-breakers were among the new products shown by J. A. Crabtree and Co., Ltd., Walsall, Staffs.

The new C-50 miniature circuit-breaker (Fig. 27 shows a cut-away view) are designed to challenge the use of rewirable fuses for sub-circuit protection. As such they can be fitted in what is claimed to be the first all-insu-

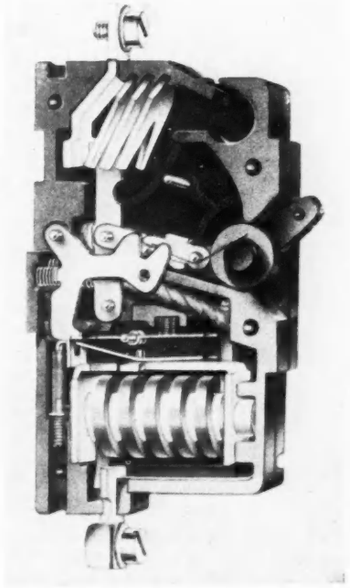


Fig. 27—Miniature circuit breaker (C-50) set to trip on 30 per cent overload and fitted with inverse time delay—Crabtree

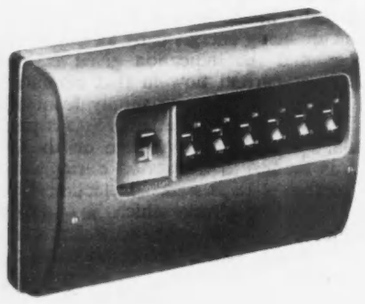


Fig. 28—All-insulated consumer's unit enclosing 60A double-pole isolating switch and six miniature circuit breakers, of ratings from 2·5A to 50A—Crabtree

lated consumers unit (Fig. 28) to give circuit-breaker protection to the sub-circuits.

The C-50 circuit breaker has an electromagnetically operated tripping mechanism, all ratings being set to trip on a sustained overload of 30 per cent. "Nuisance" tripping by harmless transient overloads is prevented by a built-in inverse time-current delay device. It will be seen from Fig. 27 that the operating handle controls the moving contact through a collapsible over-centre toggle mechanism. Since the handle is in positive control in the "On" and "Off" positions, the breaker can always be opened or closed manually.

The moving contact traverses the V-shaped slots in a series of arc grid plates at the top of the switch and is shown in the closed position in Fig. 27. The overload coil and time delay device are located in the bottom of the moulded case of the circuit-breaker.

The fully-insulated consumers unit (Fig. 28) consists of a moulded cover in a silver-grey colour, enclosing a 60A double-pole isolating switch and up to six miniature circuit-breakers, which can be of various ratings, from 2·5A to 50A.

Chloride Batteries, Ltd.

The new "gauntlet" plate construction, which Chloride Batteries, Ltd., Exide Works, Clifton Junction, Manchester, introduced into their Exide-Ironclad batteries at the end of 1959, was demonstrated. These new Exide-Ironclad batteries show a saving of approximately 25 per cent in weight and 20 per cent in both floor area and volume over the old batteries; they are now available with a multi-tubular "gauntlet" of resin-impregnated "Terylene" cloth which is slipped over the spines of CB.95 alloy of the positive plate and holds the active material in a firm but elastic grip. The bottom of the positive plate is a polythene moulding of special design to ensure that the "gauntlet" tubes are effectively and permanently sealed. The negative plates are armoured with sleeves of "Porvic."

Ferranti, Ltd.

The portable peak accelerometer recently introduced to the packaging industry was shown by Ferranti, Ltd., Hollinwood, Lancs. This instrument is used for measuring shock inside packages and the cushioning properties of packaging materials. It can also be used for measuring peak g values in vibration testing. The instrument consists of two main units, a probe for fitting on the sample under test and an indicator unit. The latter incorporates a cathode follower, an a.c. amplifier, a low-pass filter with a cut-off frequency of 675 c/s and an output socket for connecting a cathode-ray oscilloscope. It is also fitted with a double-scale, 3½in dial rectangular flush mounted indicator, with mirror scale and knife-edge pointer, giving four ranges from 0–25 g, 0–100 g, 0–250 g and 0–1000 g. Minimum readable g is 3. Manipulation of a switch on the instrument enables vibration readings from 8 c/s to 750 c/s per second to be obtained.

A characteristic of the instrument is that it can retain a reading within 2 per cent for thirty seconds, even although the actual shock pulse duration may be as short as a thousandth of a second. The acceleration sensitive element or probe consists of a barium titanate crystal accelerometer fitted in a metal housing with an output lead of screened cable, nominally 12ft long, for plugging into the indicator unit. The overall dimensions of the indicator are, length approximately 13in, height 10½in, width 6½in; the weight is about 15¾ lb.

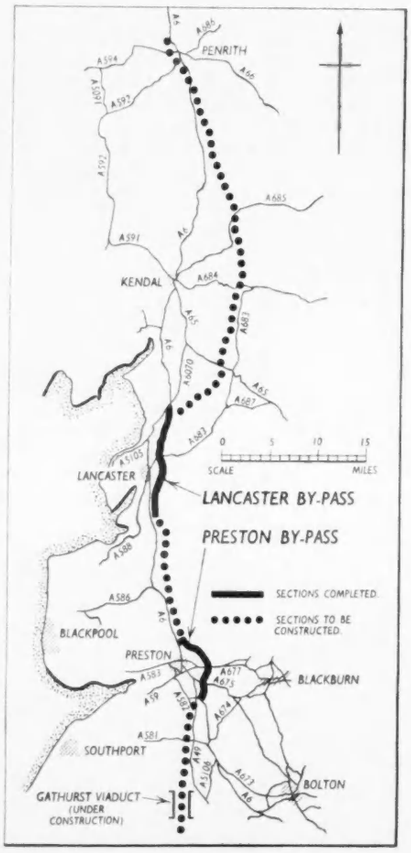
Lancaster By-Pass Motorway

Last Monday, the Lancaster by-pass was inaugurated. This motor road is about 11½ miles long, access and egress being limited to the ends of the road and to one intermediate junction. The road will eventually form a part of the motorway M6.

THE second stretch of motor road in the County of Lancashire was officially opened last Monday by the Chancellor of the Duchy of Lancaster, Dr. Charles Hill. The route of the new road is shown in the accompanying map, from which it will be seen that it by-passes the town of Lancaster, which has up till now been the centre of serious congestion, and forms part of the north–south through route, the M6. Further south is the Preston by-pass, a length of about 8 miles of motorway, which was completed in December, 1958, and was the first length of motorway to be brought into use in this country. Thus, the two by-passes now relieve the two most seriously congested towns along the north–south route, giving a measure of improvement until the route is completed. Last autumn, construction of three major viaducts on M6, between Preston and Birmingham, was started, prior to the road works themselves, which will not take so long to build as the viaducts; the road works here are due to start in June. Between the two by-passes the "scheme line" of the road has been advertised.

The Lancaster by-pass is similar in its general design to its forerunner, the Preston by-pass, which was described quite fully in The Engineer of December 12, 1958. Like the earlier road, it has dual two-lane carriageways, with a central reservation wide enough to allow widening to a dual three-lane road should this measure be needed in the future. As constructed at the moment, the new by-pass starts at a roundabout on the A6 at Hampson Green (i.e. 6 miles south of Lancaster), by-passes Galgate, Lancaster, Slyne, Bolton-le-Sands and Carnforth on the east, and rejoins A6 about a mile north of Carnforth, again at a roundabout. Its total length is 11·62 miles. It is characterised by one major structure—the River Lune bridge—and one intermediate junction, with the A683 which passes under the by-pass in the Lune Valley, quite close to the bridge. There is a sharp curve at each end of the road—considerably sharper than the normal motorway standards. The short lengths of road at the ends between each curve and the corresponding roundabout on A6 will eventually form spur roads approaching two-level junctions on the completed M6 route, and giving access to it from the A6. The roundabouts on the A6 are both 240ft in diameter.

The junction with A683 (the Lancaster–Sedbergh road) is partly shown in our second illustration. It is called a "double-U" junction and is similar to the junction of the Preston by-pass with the Preston–Whalley road which we illustrated in our earlier article. In this case, however, the two "Us" are placed slightly differently—one of them runs off to the left of the illustration, but the one on the right is clearly shown—and there are no roundabouts on the minor road. Thus, although traffic entering and leaving the by-pass does so according to full motorway standards, right turns across the traffic have to be made on A683.



The Lancaster by-pass and the proposed Birmingham-Penrith motorway

Two novel points in the design of the by-pass may perhaps be picked out before passing on to a general description, since they may have some bearing on the widely-publicised failures of the Preston by-pass carriageways, where it may be recalled, damage to several patches of the carriageways was caused by frost (see The Engineer, February 6, 1959, page 226).

First, surface water discharging from the carriageway is carried into gullies in a combined concrete marginal strip and drainage channel which has an overall width of

24in. This feature has not been introduced previously in motorway construction, its object being stated to be to ensure maximum efficiency of discharge into the piped drainage system, and to prevent discharge on to the hard shoulders and verges. Flush concrete marginal strips are provided on the high side of the carriageways, 20in wide where they are in their permanent position and 12in wide where they have to be removed when the carriageways are widened. And, secondly, the "wet-mix" or premixed water-bound macadam, to give it its full title, had cement added, one part in sixty by weight.

Some of the principal design data for the by-pass are given in the table. The countryside through which the road passes is attractive, and corresponding care has been taken in alignment, and in a landscaping scheme which has still to be carried out.

Design Data and Quantities for Lancaster By-Pass

Design speed	70 m.p.h.
Minimum overall width	112ft
Width of carriageways	24ft
Minimum width of verges	12ft 6in*
Width of central reservation	39ft*
Ultimate width of central reservation with 3-lane carriageways	15ft
Minimum radius (except on temporary bends)	2,865ft
Maximum gradient	1 in 30
Maximum depth of cutting	45ft
Maximum height of embankment	50ft
Excavation	3,100,000 tons
Imported filling	800,000 tons
Gravel and crusher sub-base	360,000 tons
Premixed waterbound macadam	140,000 tons
Hot rolled asphalt	70,000 tons
Sewers and culverts	62,000 linear yards
Concrete	70,000 cubic yards
Reinforcement steel	1,500 tons
Structural steel	130 tons
High tensile prestressing-wire	620 miles
Prestressed concrete bridge beams	65,656 linear feet

* Includes marginal strips.

There are crossings on the central reservation, for maintenance and emergency usage, generally at 2-mile intervals. Steel fenders are provided at critical points such as on high embankments. Marker posts indicate mileage from Hampson Green; there are reflective strips on the top 12in of each post, and the posts are positioned 10ft off the carriageway. There will be a service area at Hampson Green, it is planned, later on when M6 is complete.

The carriageways are designed to carry the heavy loading specified by the Ministry of Transport. Subsoil conditions vary considerably throughout the length of the by-pass, ranging from peat and clays of varying qualities to rock. Construction depths vary from 12in in the rock areas to 36in. The sub-base is partly of gravel and partly of crusher run limestone. The base of the carriageway consists of 8in of premixed waterbound limestone macadam with cement added as already noted. The surfacing consists of two course hot rolled asphalt 4½in thick, comprising a base course 3in thick and a wearing course 1½in thick with precoated granite chippings applied to the surface to provide a high resistance to skidding. The only temporary surface is on the sharp curve near Hampson Green where fine cold asphalt has been laid.

The road climbs to a maximum height of about 300ft above sea level, with views over the sea and the Lakeland hills. The highest embankment is just over 40ft in height, and the deepest cut about 30ft. The total quantity of excavation was about 1,700,000 cubic yards, including over 160,000 cubic yards of peat. The peat lay to a depth of 18ft in a former marsh at the north end of the road, where it was replaced by a cobble-stone bottoming.

Bridges

There are twenty-seven bridges altogether on the by-pass, but the River Lune bridge is by far the outstanding structure of the whole scheme. Its general construction and graceful appearance are well shown in the illustration. The arch is in reinforced concrete, and has a clear span of 230ft. Centering was erected over the full width of the arch to construct the bridge. The arch rises 44ft, and, as may be seen, it has open spandrel bracing carrying the motorway. The total length of the bridge is 400ft, and it is 97ft wide between parapets. Note also the railway and pedestrian bridges.

A typical bridge on the motorway can be seen in the general view of the road. Eight such bridges carry public roads and four carry "occupation" roads and footpaths over the motorway. Thirteen carry the motorway as follows: seven over public roads, one over a canal, two over railways, and three over rivers. Finally, one carries a railway over the motorway, and one an "occupation" road over a railway.

A typical length of the motorway. The Lune bridge and the A683 junction can be seen in the background

With the exception of the Lune bridge, two steel-decked bridges, and one other bridge in reinforced concrete, all the bridges have prestressed concrete decks; loading, choice of spans, and so on, follow normally accepted practice. Only the railway bridge has solid parapets.

The Lancaster by-pass was designed and built under the supervision of Mr. James Drake, M.I.C.E., the county surveyor and bridgemaster of Lancashire County Council. This was done in co-operation with the Ministry of Transport's chief engineer, Mr. J. F. Baker, M.I.C.E., and the Ministry has paid the full cost of the road. The railway bridge was designed by the chief engineer of the London Midland Region.

The main contractor for the by-pass was Sir Lindsay Parkinson and Co., Ltd., whose contract price was £3,830,962. Work started in July, 1957.

The River Lune bridge with the junction with A683 partly shown in the background

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PEAK LOAD GAS TURBINES WITH AIR STORAGE

SIR,—The article under the above title in your number of March 11, 1960, by Messrs. Wood and Wick is to be welcomed. It does much to clarify thought about a proposal that deserves detailed study, and that may well prove in future to be the most economical means of generating a portion of the peak load. With this proposal, as is made clear in the article, peak load energy is generated by gas turbines and the compressed air needed by them is provided from a separate source, and at a time when the gas turbines are not generating. This relieves the gas turbines of the work of compressing the air, which is for them an auxiliary service, and makes their gross output available for generating electricity. In consequence the cost per kilowatt of the generating plant is very low. But the installation is burdened with the cost of providing storage space for the compressed air and a water head for maintaining constant pressure.

As the authors of the article rightly say, the most important competitor to this proposal is pumped storage. But I think that the authors are not quite fair to the gas turbine when they base the comparison on a generating time of four hours. Some estimates that I have made do not differ very widely from those in the article, but differ sufficiently to make the comparison unfavourable to the gas turbine if so great an average generating time is assumed. But even my more pessimistic estimates show the gas turbine in association with compressed air storage to compete successfully with pumped storage provided the average generating time is shorter. This needs a few words of explanation.

Any storage scheme must provide both firm kilowatts and firm kilowatt-hours. The latter are proportional to the area occupied by the peak that is served by the plant. For this reason, capacity related cost estimates for any sort of storage scheme should be broken down into the following components :

(*a*) The capacity related cost that is directly proportional to the kilowatts of plant installed. It covers generating plant, pipes, tunnels, and similar items.

(*b*) The capacity related cost that is directly proportional to the kilowatt-hours generated on any one occasion. It covers everything needed to provide the requisite storage such as the civil engineering works for providing upper and lower reservoirs on a pumped storage scheme and the cost of providing a cavity for storing compressed air.

For a gas turbine installation associated with compressed air storage (*b*) is rather high per kilowatt-hour of peak generation. For pumped storage it is quite low. On the other hand (*a*) is low for compressed air storage and comparatively high for pumped storage. From this it follows that there is a break-even point between the two proposals at a certain ratio of kilowatt-hours generated to kilowatts used to generate them. According to my estimates the break-even point occurs roughly when this ratio is between unity and 1·5 ; in other words when the average generating time is from one to one-and-a-half hours.

According to my more pessimistic estimates, a compressed air storage installation designed for an average peak load generation of four hours per day could, therefore, not compete successfully with a pumped storage installation economically equivalent to Ffestiniog. But the number of kilowatt-hours generated per kilowatt depends on the fraction of the system maximum demand that is taken by the peak load plant in question. For the British Grid System the ratio of kilowatt-hours to kilowatts is about two when this fraction is 5 per cent, and about unity when the fraction is of the order of 1·5 per cent. According to the estimates of Messrs. Wood and Wick one could thus justify the gas turbine proposal for more than 5 per cent of system maximum demand, whereas the conclusion from my figures is that gas turbines in association with compressed air storage would provide peak load plant more cheaply than pumped storage equivalent to Ffestiniog if used to generate the extreme peak only, but that it would be bad economics to provide sufficient storage to permit generation of more than a few per cent of system maximum demand. But on the most pessimistic estimates there seems to be an economic case for some hundreds of megawatts of gas turbine plant associated with compressed air storage.

The percentage economically provided may, however, increase in the course of time. For eventually all the sites suitable for pumped storage in this country will have been developed. Further peak load plant may well then be best provided by gas turbines. In this connection it should be remembered that the storage chamber does not need to be in a mountain. It can be excavated below level earth, and on sites where the water seal can be constructed cheaply and easily. Compressed air storage installations will, therefore, be possible nearer to load centres than most pumped storage installations.

Messrs. Wood and Wick advocate the provision of an aftercooler. I fully agree, but should like to add an economic reason for it to the practical one that they mention. They point to the disadvantage of introducing hot air into the cavity, and emphasise the risk that the water might boil as it loses pressure in coming up the shaft. A further very important reason for aftercooling is that it allows a greater mass of air to be stored per cubic foot of cavity.

REGINALD O. KAPP

London, S.W.1,
April 6, 1960.

AFTERMATH OF GUILLEBAUD

SIR,—How refreshing to read your leader of March 18. I wonder if your comments have been noted by the B.T.C. Executive. The present deteriorating position of the railways calls for much serious consideration. This consideration is undoubtedly taking place, but it seems, alas, only able to produce reasons why British Railways cannot pay their way rather than ways and means of making a reasonably solvent, if somewhat contracted, system.

Relative operational efficiencies quoted during the British Association's meeting last year at York, give a very good indication of how far British Railways have fallen behind certain Continental operators. Conditions may not be exactly similar, but the discrepancies are so great as to throw grave doubts upon the operating efficiency of our railways. For several years we have now heard the rather wearisome reiteration that "modernisation" will put everything right, but despite the expenditure to date there is painfully little real improvement to be seen.

It is noteworthy that much of the G.P.O. parcels service is carried by the railways, yet it is an excellent system ; why, therefore, cannot an equally good service for parcels and smalls be provided by the railways themselves ? Surely it is possible to improve general freight services with mainly existing equipment rather than heavy expenditure on new plant. The cost of new locomotives and rolling stock is prodigious (we hear of 1350 h.p. diesel electric locomotives costing £84,000).

M. W. BURNBY

Sheffield,
April 6, 1960.

THEORY OF MACHINES

SIR,—Mr. Helmer's article in your issue of March 25 was interesting to us at Imperial College. During the last few years we have had the same doubts about some aspects of the subject as it has been taught, and our teaching is at present being changed on lines very similar to those Mr. Helmer describes. Our objective is to teach the fundamentals of kinematics and dynamics, with applications of present-day relevance, but we have kept the title "Theory of Machines" because we think that this is the Theory of Machines which matters.

We do not, of course, regard our present mild reformation as final, but even now we are meeting a problem which presumably exists also at Southampton, but on which Mr. Helmer is silent ; the real intellectual content of the course has been increased, and as the same process is happening in other subjects, more students are in danger of mental indigestion. Who will be the first to offer to drop a large part of his own subject ?

S. A. V. SWANSON

City and Guilds College, S.W.7,
April 8, 1960.

Book Reviews

Impulse Voltage Testing, Vol. XV. By W. G. HAWLEY. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 32s.

THE book under review is the first to be written on the subject. It is a useful and timely book and gives a complete coverage of all topics of industrial impulse voltage techniques. After dealing with the generation of impulse voltages and the performance of single- and multi-stage generators, the measurement and the recording of impulse voltages are dealt with. This is followed by a treatment of the various industrial tests, such as impulse tests of insulators, transformers, overhead lines, power cables and capacitors. The book concludes with appendices containing useful numerical data and a short bibliography for the more serious reader. For workers in this field some facility in tackling simple transient problems is essential and it is commendable that the author has included in the book sufficient of the basic transient theory, treated in terms of Heaviside's operational calculus. He has taken pains to present his theoretical matter in a simple way and at a level well within the grasp of the practising engineer. The diagrams are well produced and there are very few typographical errors. The presentation throughout is lucid and the text is easy to read. Altogether, this is a good book which can be strongly recommended to laboratory staff engaged in this type of work and also to students of engineering schools and colleges where this subject is now taught.

Aluminium Busbar. By A. G. THOMAS, B.Sc.(Eng.), and P. J. H. RATA, B.Sc. (Eng.), A.C.G.I. Hutchinson and Co. (Publishers), Ltd., 178–202, Great Portland Street, London, W.1. Price 21s.

THIS is a comprehensive handbook, published for Northern Aluminium Company, Ltd., on the design, construction and installation of aluminium and aluminium alloy busbar. General design considerations are reviewed, followed by chapters which deal with the factors influencing the choice of conductor shape for both d.c. and a.c. applications and associated problems, such as skin-effect and proximity-effect, current distortion, &c. Determination of reactance is discussed as are also the various forces acting on a busbar, and there are notes upon the isolated-phase busbar and operations of bending and forming. A final chapter considers the problems of jointing and connecting, and the book has an extensive appendix, including tables giving both mechanical and electrical particulars.

Nuclear Reactor Materials. By B. R. T. FROST, B.Sc., Ph.D., and M. B. WALDRON, B.Sc., Ph.D., A.I.M. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 12s. 6d.

THIS book, one of the series of "Nuclear Engineering" monographs, outlines the properties of reactor materials to introduce physicists and engineers to the possibilities and limitations of the materials with which they have to work. Its effectiveness as an introduction to the subject is enhanced by a useful bibliography. The book opens with a chapter on modern metallurgical theory and goes on to deal with structural materials, fuel, canning and moderator materials, liquid metals, ceramics, metal-ceramic mixtures and corrosion.

The text is based on a series of lectures given by staff of the metallurgy division, Atomic Energy Research Establishment, Harwell, to students in the department of nuclear engineering at Queen Mary College, London, E.1. The chapter on ceramic materials was contributed by J. Williams, and the chapter on gaseous and aqueous corrosion by J. N. Wanklyn, both of Harwell.

Since this book is clearly a short introduction to the subject it would be harsh to criticise it on account of its omissions. Nevertheless the reader may be disappointed to find that he must look elsewhere for information on materials specifically used in organic moderated reactors and solid homogeneous research reactors. Some defects are evident in the compilation of the index; for example, there is no reference to "moderators" and "reflectors," and the entry for "graphite" is incorrectly given as page 59.

However, these are but minor blemishes in a well-written book which deals concisely with its subject matter.

Motor Cars: Handbook of the Collection. Part II. By C. F. CAUNTER. The Science Museum. H.M. Stationery Office. Price 10s. 6d.

PART II of the *Handbook of the Collection* illustrating motor cars, the catalogue of exhibits with descriptive notes, complies with the style established by this curator in previous volumes. It is strictly descriptive and not explanatory. The hall-mark of these volumes, an index composed overwhelmingly of proper names, persists; in ten columns eighteen entries commence with common nouns, and two of these are misprinted.

The issue of the catalogue may be beneficial in drawing attention to the rather pathetically haphazard composition of the collection. Amongst the cars there is not a Bugatti, a Citroen, a Cord, a Lancia, a Mercedes, nor a Volkswagen. There is not a nickel-cadmium battery, a high-speed distributor with separate making and breaking points, a modern dynamotor, a petrol injection system, nor a rigid breaker tyre. It is barely credible that an important collection in Great Britain should be devoid of the work of W. O. Bentley; since the collection is notably weak on modern products, on electromagnetic transmission, and on independent suspension, one would most earnestly wish to see urgent efforts made to secure a 2½-litre Lagonda as designed by Bentley. But the finance available to the museum is so limited that it must depend primarily on gifts in acquiring exhibits. In such circumstances, there is little to be wondered at if much that ought to be on view is not represented.

Books Received

Chemistry for Engineers. An Introductory Course. By E. Cartmell. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 25s.

Rules and Regulations for the Construction and Classification of Steel Ships, 1959. Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. Price 42s.

Chemical Engineering Practice. Volume II. *Works Design, &c.* General Editor, Herbert W. Cremer; Managing Editor, Sidney B. Watkins. Butterworths Scientific Publications, 4 and 5, Bell Yard, London W.C.2. Price 95s.

Annotated Equilibrium Diagrams of Some Aluminium Alloy Systems. Institute of Metals Monograph and Report Series No. 25. By H. W. L. Philips. The Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 30s.

String Figures and Other Monographs. Third Edition. By W. W. R. Ball, J. Petersen, H. S. Carslaw and F. Cajori. Chelsea Publishing Company, 50E, Fordham Road, New York 68, N.Y. Price 3 dollars 95 cents.

Technical Reports

Factory Building Studies No. 4: "Structural Loading in Factories." H.M. Stationery Office. Price 1s. 9d.—Four years ago the Building Research Station started a series of investigations into the special needs of factory building, and this report is the fourth in this series. Loading conditions in the modern factory in which much of the production plant, service equipment, transport and goods may either be carried by the floor, or suspended from above, are not fully covered by existing codes of practice. Nevertheless, failure to make reasonable allowance for such loading conditions will restrict the adaptability of a building to improvement or change. The information in this report thus supplements the codes by giving more details of various kinds of load for which provision may have to be made, with some indication of typical ranges of size, weight and performance of the equipment concerned. The equipment considered includes that for heating and ventilation, lighting units and power distribution, piping, handling plant, machinery and tools.

Low-Speed Wind-Tunnel Tests on the De Havilland "Sea Venom," with Blowing Over the Flaps. S. F. J. Butler and M. B. Guyett. Reports and Memoranda No. 3129. H.M. Stationery Office. Price 20s.—This report contains the results of low-speed tunnel tests of longitudinal stability of a modified "Sea Venom" Mk. 21, fitted with blowing over the flaps. At each flap angle, a range of values of the sectional momentum coefficient was tested. As a typical example, the increase in trimmed C_L at constant incidence resulting from blowing at flaps 60 deg. was about 0·45, the increase in C_{Lmax} being somewhat smaller. The equivalent reduction in approach speed of 10kt to 15kt predicted from the tunnel results was later achieved in flight. The tunnel results suggested a beneficial reduction in minimum-drag speed due to blowing, particularly at large flap angles. Trim changes were large, amounting to about 8 deg. on the all-movable tail at flaps 60 deg.

A comparison is made between estimated and measured effects of blowing. It is shown that, whilst the lift and pitching-moment increments resulting from flap blowing can be estimated fairly closely, the drag increments at large flap angles are much larger than would be expected. The additional drag tends to decrease the minimum-drag speed and increase the minimum drag, and may affect the take-off and landing performance appreciably. The effect will be unfavourable in the first case and favourable in the second.

A flight/tunnel comparison is included of the lift increments resulting from blowing. At flaps 40 deg., agreement is good, but at larger flap angles the lift increments measured in flight were less than those measured on the model. Possible reasons for this are discussed. There is a favourable Reynolds number effect on C_{Lmax} which is found to be somewhat larger for the blown flap than for the unblown flap.

An Approximate Method of Calculating the Laminar Boundary Layer in Two-Dimensional Incompressible Flow.

Approximate Calculations of the Laminar Boundary Layer with Suction, with particular reference to the Suction Requirements for Boundary-Layer Stability on Aerofoils of Different Thickness/Chord Ratios. M. R. Head. Reports and Memoranda Nos. 3123 and 3124. H.M. Stationery Office. Price 20s. and 7s.—In the first report an account is given of an approximate method for calculating the incompressible laminar boundary layer in two dimensions. Application of the method to the various cases for which exact (or nearly exact) solutions were available gave results which are in all cases in very satisfactory agreement with the accepted solutions. The accuracy of the method (essentially a development of one given earlier by Wieghardt) evidently results from satisfying both the momentum and energy integral equations of the boundary layer, together with the first compatibility condition at the surface. The doubly-infinite family of velocity profiles used in the method was obtained by a numerical procedure which gave a very much wider range of physically acceptable profiles than could be achieved by the use of simple analytic expressions (e.g. polynomials).

In the second paper the approximate method has been applied to the class of problems for which it was specifically devised, namely, problems where suction (or blowing) is applied through the surface.

In Part I solutions are given for the following cases:

(*a*) Flat plate with uniform suction and sinusoidal variation of external velocity.

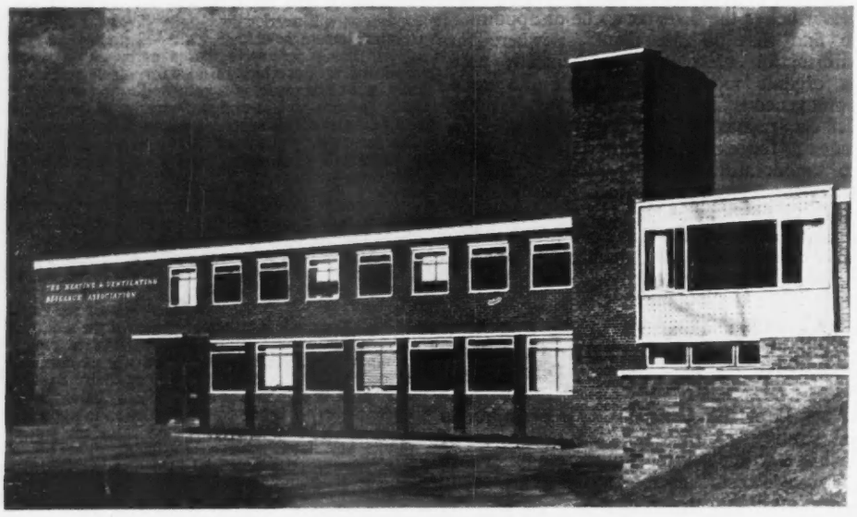
(*b*) Flat plate with intermittent suction.

(*c*) Suction applied following the normal separation point to maintain a zero skin-friction layer for the flow $U=1-x$.

(*d*) Flat plate with uniform blowing.

In Part II results are given of comprehensive calculations for a series of aerofoils with related pressure distributions. The distributions of suction required to maintain neutral stability of the boundary layer are given as functions of thickness/chord ratio and Reynolds number. The effect of Mach number is also inferred on certain simplifying assumptions.

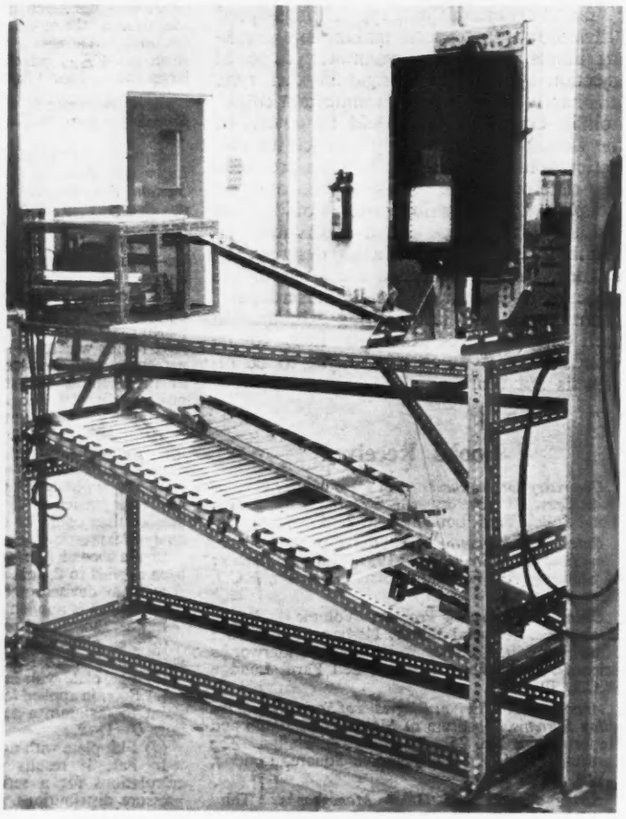
Heating and Ventilating Research Laboratory



The Heating and Ventilating Research Laboratory at Bracknell

SINCE its inauguration on December 29, 1955, the Heating and Ventilating Research Council has, as a temporary measure, rented laboratory space in the laboratories of the British Coal Utilisation Research Association at Leatherhead. During the following years the support forthcoming from the industry had assured the permanence of the organisation and enabled a research programme to be formulated. This progress enabled full Research Association status to be applied for and July 15, 1959, marked the incorporation of the Heating and Ventilating Research Association. To meet the need for facilities to carry out a research programme and for further accommodation, a site was acquired at Bracknell, where a permanent laboratory and offices have been built. These were officially opened by Lord Hailsham, on Wednesday, April 6, who, in the course of his remarks, reviewed some of the major items of research currently in hand. The chairman of the Association briefly mentioned developments since 1955 and thanked the D.S.I.R. for its assistance in making possible the formation of the Association and the building of the laboratory.

The new building, which we illustrate, was designed by Mr. E. A. Ferriby, architect of the Bracknell Development Corporation, and consists of a two-storey office block with an open laboratory, having a floor area of 4000 square feet, behind. By leaving the laboratory free of partitions, it is possible to use considerable lengths of piping or ducting for experimental purposes. The exhibits on view in the laboratory on the opening day illustrated the research programme currently in hand and which can be broadly divided into heating, ventilation and air conditioning, operations research, physical and chemical problems, together with an information service.



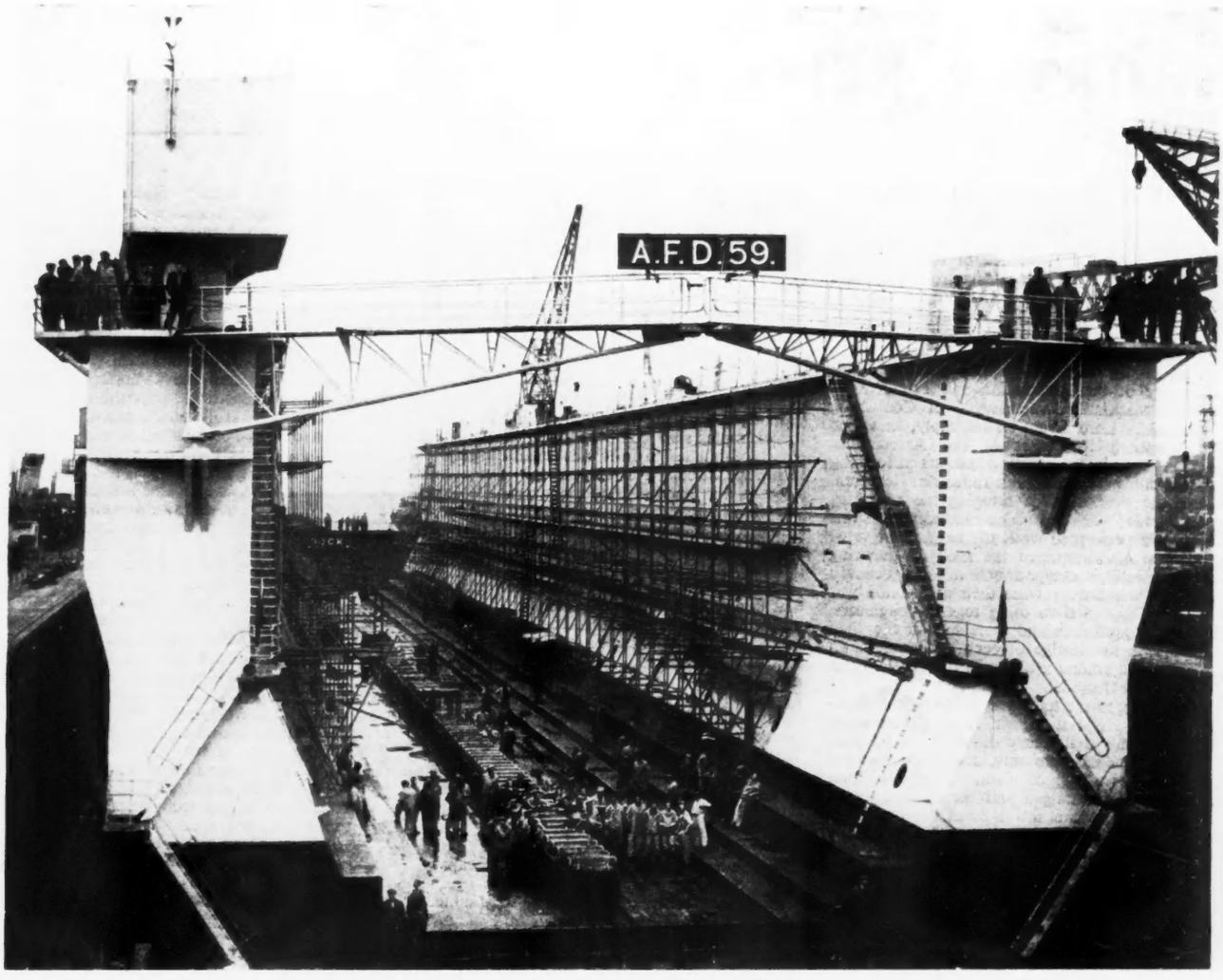
Queueing simulator for operational research

Intermittent heating is being studied by observation of its use in actual buildings and supported by a theoretical attack on the problem. An example of this is the examination of designs of block heating and floor-warming systems using off-peak electrical supplies. This question of intermittent heating has called for the study of the thermal properties of structural materials and of the heating system and this is being done by an electrical analogue which translates the transient response of building elements into data for estimating the cooling loads. A hydraulic simulator demonstrates the variations of temperature within a room which is being heated on an intermittent basis. Based on full-scale observations, a method of pre-heat control is being examined, and in this scheme the control is designed to vary the time of operation of an automatically-fired boiler, as determined by the average temperature of the building at a selected time before occupation. This enables an equable temperature to be attained by the time the staff arrive, allied with a maximum economy of fuel. An apparatus to determine the flow characteristics of radiator valves illustrates part of the work connected with the adoption of smaller bore pipe and higher water speeds for hot water heating systems, for the design of which data on pressure drop in pipes, fittings, valves and radiators is required.

To expand existing knowledge related to ventilation and air conditioning, work is going forward on acoustics, pressure drop in ducts, and problems concerned with high velocity air distribution. As part of the work on pressure losses at high speeds, the performance of less conventional materials is being observed and an exhibit demonstrated an experiment to determine friction losses in a rigid p.v.c. tube at air speeds up to 10,000ft per minute. Fan noise problems are being examined and at present the sound power output frequency characteristic of fans is being determined in a rig which includes an anechoic chamber, a reverberant room and a test duct. Ventilation systems are illustrated by a single duct induction unit in which the air is heated as required and the room supply consists of about three parts of recirculated air and one part fresh air. A dual duct mixing unit, on view, involved the provision of practically 100 per cent fresh air supply. In this unit a sample of room air is entrained to operate a thermostat which controls the hot and cold dampers to admit more warm or cold air as required, while a volume controller maintains normal air pressure.

Attention is being paid to operational research to effect economies in installation costs by standardisation and prefabrication of parts and procedure. An example of such work is the queueing simulator, illustrated herewith, which has been designed to show at what point an increase in utilisation of a screwing machine may become uneconomic owing to queueing. Here balls of various sizes represent a range of similar jobs, each of which requires a specific period of time on a screwing machine as represented by a slope down which the balls run in a known time. This is proportional to the time spent at the machine. The balls are introduced into the system at random intervals, to represent the arrival at the machine, a rotating disc providing the sequence, and after arrival the balls pass to the queueing area and are held there until the machine is free. By use of the simulator the average queueing time can be found for different utilisation ratios and the scale time is such that a day's work can be simulated in about forty minutes.

Efforts are being directed to develop a rational method of evolving the size of chimneys, and to prevent corrosion by condensation, while a model demonstrates a study of the disturbances caused by wind such as to prevent the proper dispersal of gases from a chimney. This visual flow demonstration reproduces local conditions and assists in determining the optimum position and height of the chimney. Another instrument in the laboratory makes " spot " measurements of air change rate.



This floating dock, "launched" on March 31, is intended for use in fitting out nuclear-powered submarines and for routine maintenance. Accommodation and living facilities are of particularly high quality

Admiralty Floating Dock

By OUR NAVAL CORRESPONDENT

AFTER building for fifteen months in a dry dock at Portsmouth Dockyard, a virtually new type of floating dock was "launched" on March 31 by the Lady Carrington, wife of the First Lord of the Admiralty. The procedure of "launching" the floating dock entailed the setting in motion of the machinery for flooding the dry dock where she was built and thus floating her out. This was done by Lady Carrington immediately after the ceremony. Though capable of lifting all existing destroyers and frigates, the new dock was specifically designed to deal with nuclear-powered submarines. Until we have more knowledge of the risks entailed in installing nuclear reactors and changing fuel elements, it is essential that a vessel, while they are being installed, should be in a safe place, far removed from the wharf or jetty in a populated shipbuilding yard. Hence, it has been necessary to provide quarters for the ship's company of the vessel in hand, in addition to the normal accommodation required for the dock's crew. It will thus not only be fully equipped to carry out routine maintenance and repairs of ships docked in it but will be provided with accommodation and living facilities to the latest habitability standards, including air conditioning and fluorescent lighting in all cabins messes, for about 200 hundred officers and men.

In view of the heavy additional cost of providing a floating dock of this nature, Admiralty Floating Dock No. 59 is a clear indication that Britain is no longer to be content with one, or even two nuclear-powered submarines and that in due course, when finances permit, we may expect a flotilla of "Dreadnoughts." It might also be more economical to use her for the refits of destroyers, frigates and submarines in ports where there are no naval barracks available.

The dock is 400ft long, 77ft wide and 65ft high, and seems capable of docking larger submarines than the "Dreadnought," which is based on the United States "Skipjack"—a vessel of 2850 tons, 250ft in length and 31ft 6in beam, and with a ship's company of eight officers and seventy-five men. But it is not clear whether, in stating that "the dock is capable of lifting submarines of the latest types," the Admiralty include the United States rocket launching submarine, "George Washington"—a vessel of about 5600 tons and 380ft in length. Extensive use has been made of prefabrication, and the completion of the structure within fifteen months represents a considerable achievement, more particularly as the work was carried out in a dry dock which lacked many of the facilities normally associated with a building slip. Assistance in fabrication of certain fittings was given by Chatham and Rosyth dockyards. A push-button control system will be installed for the operation of the dock and the main pumps for controlling the raising and lowering of the dock will be capable of dealing with over 200 tons of water per minute. Instruments will be fitted to record for the Dock Master's information the strains coming on the structure during the docking operation. Four main generators and two auxiliary generators supply 1320kW for the main pumping machinery, lighting, &c. This power supply is sufficient for the domestic load of a vessel in the dock and power and lighting for repairs in addition to the dock services. The dock will be equipped with special sliding keel blocks for the docking of submarines. A 7½-ton travelling crane is situated on, and runs the full length of, each dock wall.

Ship Auto-Pilot

SEA trials, while sailing from Glasgow to Liverpool, have been carried out by the M.V. "Ajax," a cargo liner of the Blue Funnel Line, which has been equipped with an Arkas J.O.3 Automatic Helmsman supplied by The Decca Navigator Company, Ltd. During the voyage the Auto-Pilot was subjected to stringent tests, including a simulated power failure when manual control of the ship was regained in sixteen seconds. The equipment enables the ship to steer a more precise course, and can operate from either a magnetic or gyro compass while the control unit electronically applies automatic counter-rudder to hold the ship on her course with only three or four rudder movements per minute. The equipment is to undergo extensive evaluation trials during a voyage to the Far East.

SHORTER REPORTS

Diesel Engineers and Users Association Luncheon

THERE was an attendance of nearly 300 at the luncheon of the Diesel Engineers and Users Association held at the Connaught Rooms, London, W.C.2, on April 7, when the guest of honour was the Rt. Hon. the Viscount Bruce of Melbourne. The toast of "The Guests" was proposed by Mr. Julian Tritton, Honorary Secretary of the Association and President of the International Confederation of Consulting Engineers. Lord Bruce in his reply, in which he proposed the toast of the Association, recalled some of his wartime labours in forming a Council for Scientific and Industrial Research. Once the difficulties of bringing the necessary people together had been surmounted, this body had performed work of the greatest value and was an example of the need for securing co-operation in every direction. He believed that this was exactly what their association was doing. They tried to bring together engineers, designers, producers and users so that they had a common knowledge of each other's requirements and a common object in the development of the diesel engine.

The reply to the toast was made by the President of the Association, Mr. James Calderwood. He said that in its early days the Association had been one of users only, and of users of the bigger, heavier type of plant. Later the structure had been changed and the makers joined them. There was still one point he would like to improve. In the past they had been mainly an association of heavy diesel engine users. In the past fifteen or twenty years the whole pattern of users had changed and he would like to see the Association bring in more users of what he would call the "portable" engines to distinguish them from heavy, slow-speed plant. He would welcome many more British and overseas railway users of diesels and many more contractor users. Their association had been built up on the discussion of problems, and its whole purpose would fail if they did not continue to have a large proportion of papers with a practical approach. Next year they were hoping to get at least one paper on the problems of the contractor's engine, and one on a railway subject. Their object was to get together as many people as they could to discuss their problems and by mutual help to create better machinery for the future than they had had in the past.

Steel Plate Mills

A TWO-DAY meeting of the Iron and Steel Institute's Engineers' Group was held in London last week, at which four papers dealing with various aspects of plate-mill design and layout were discussed. One of these papers, contributed jointly by Mr. M. F. Dowding, Mr. C. Sturdy and Mr. A. A. Thomas, points out that present-day requirements of metallurgical specification and dimensional tolerance have led to the introduction of new equipment in recent plate mill installations. The first conclusion drawn by the authors of the paper is that a modern plate mill should comprise a single four-high mill, two-high rougher, and four-high finisher or two four-high mills or a semi-continuous (one rougher and four or more four-high finishers), depending on output and order book make-up. The mill should be fed by continuous reheat furnaces with possibly one or two in and out furnaces to deal with "the awkward 10 per cent of orders." The paper goes on to say that the finishing mill should always be four-high; adequate main drive power must be installed to make sure full benefit is taken of heavy reductions. Another matter emphasised in the paper is that great attention should be paid to the proper location of high pressure water sprays at all descaling stations to ensure a clean plate throughout the operation. Finishing equipment, it is urged, must be laid out generously for modern high outputs. Rocking blade shears should be used instead of normal guillotines and rotary side trimmers for all plate ¼in thick and below and normalising facilities and cold levelling equipment should be installed.

A paper on plate mill design and layout, presented by Mr. A. Marshall, asserts that a modern plate mill is a much more complex and efficient unit than was ever visualised twenty years ago. Some of the most important factors, for example, slab conditioning, slab handling, details of mill design and kinds of finishing equipment, are discussed in the paper. The author suggests that some of the ideas which he has set out may already be outdated for, he says, "advances in design are so fast that they can outstrip the speed at which ideas can be incorporated in a mill installation."

Dealing with plate mill layout, the paper says that in any large integrated steel works, space is usually at a premium and therefore the engineer responsible for laying out a modern plate mill is normally confronted with many problems. Almost without exception, layouts are affected by local geography and therefore the ideal is rarely achieved. Apart from installing the correct machinery to produce the right product, the most valuable asset in any plate mill is space. Distances between furnaces and mill can be excessive but usually there is good reason for this, e.g. as at Consett, to allow for the future installation of a 160in roughing stand and a heavy edger. In order to overcome this, a very fast rope-hauled bogie is being installed capable of speeds up to 600ft per minute. Changes of direction, no matter for what purpose, should be avoided since they involve expensive equipment and expense in doing work. Distribution of plates to and from shearing lines is most important and particular attention should be paid to discharge of material into the sorting and loading bays. For an output of 10,000 tons of plates per week a sorting and loading area of some 100,000 square feet is necessary. An advantage in some layouts has been to have a sunken loading dock, thus enabling the slinger on the floor to see inside the wagons.

Since the loading-bay cranes are probably the hardest worked, particular attention should be paid to their design. The most useful type is the rigid, rotating-mast crane, equipped with magnet beam and power-adjusted magnets. These units may be expensive but give the operator that degree of control and flexibility essential for speedy and efficient working.

The advent and rapid development of road vehicles of all shapes and design must also play an important part in any modern mill layout. Road access to any vital part of the plant is a distinct advantage and, if possible, should be provided. Apart from the main features of plant, many smaller problems face the engineer, such as fuel supplies, offices and amenities for staff and workmen, communications, maintenance shops and stores, water-treatment plant, and a host of minor details essential for an efficient high-production unit.

The other two papers discussed at the meeting deal with "Plate Mill Furnaces" and "Developments in Electrical Equipment for Reversing Plate Mills." The information presented in the first of these was collated by the Society of Furnace Builders. The paper describes the operating characteristics of the different kinds of furnaces generally used in plate mills. In addition, the principal factors controlling the selection of furnaces for a plate mill are dealt with. These factors are defined as: quality, size and thickness of plates to be produced; required annual rate of production; form or shape of material to be initially fed to the mill, i.e. ingot or slab; dimensions of ingots or slabs and variations likely to occur in them; type and layout of mill and floor space available for furnaces, and processes of heat treatment required at the finishing end of the plant. It is emphasised that careful consideration of these factors will usually indicate clearly the particular furnaces required for optimum conditions of production.

The paper on electrical equipment was prepared by Mr. H. S. Brown and Mr. A. P. Baines. They point out that the essential functions performed by the electrical equipment on modern plate mills are basically unchanged from those performed by the electrical equipment on plate mills installed thirty years or more ago. Since these early installations, however, there has been steady development which has accelerated over the last decade. Recent developments, with particular reference to control systems, are reviewed in the paper. The problems of automatic control are treated in some detail. The authors say that two main trends are clear: the increased use of static devices for power supply and for control and a continued increase in the scope of control systems and information handling systems to aid the human operator by carrying out, on his behalf, more and more of his controlling functions. These two trends will characterise the development of electrical equipment for plate mills over the next decade. Static devices will continue to replace moving components including relays and switches as well as machines. This, together with the use of improved fault-finding techniques and plug-in unit assemblies, will reduce shut-down time in spite of more complex circuits. Extension of the coverage of control systems will first be to the automatic control of a single mill unit. It will, however, rapidly extend beyond that to the co-ordination of several mill units in a production line and integration of the control of mills with the processes before and after the mills. This field of development will have one very important aspect: the co-ordination of several engineering and administrative activities, which so far it has been possible to allow to proceed separately to a very large extent. In future, the paper adds, there will be an increasing need to carry out the mechanical and electrical engineering and the production planning as a single co-ordinated operation. Only by the close co-operation of manufacturer and user, designer and operator, will the full benefits that control system development offers be obtained.

High-Speed Resistor Tap-Changer

WE illustrate a new design of high-speed resistor tap-changer for transformers. It has been developed by The English Electric Company, Ltd., Marconi House, Strand, London, W.C.2, to meet the needs of high-voltage transmission systems up to 500kV with currents up to 1000A. The first installation of these tap-changers will shortly be made at the 275kV substation of the C.E.G.B. at Iver, Bucks.

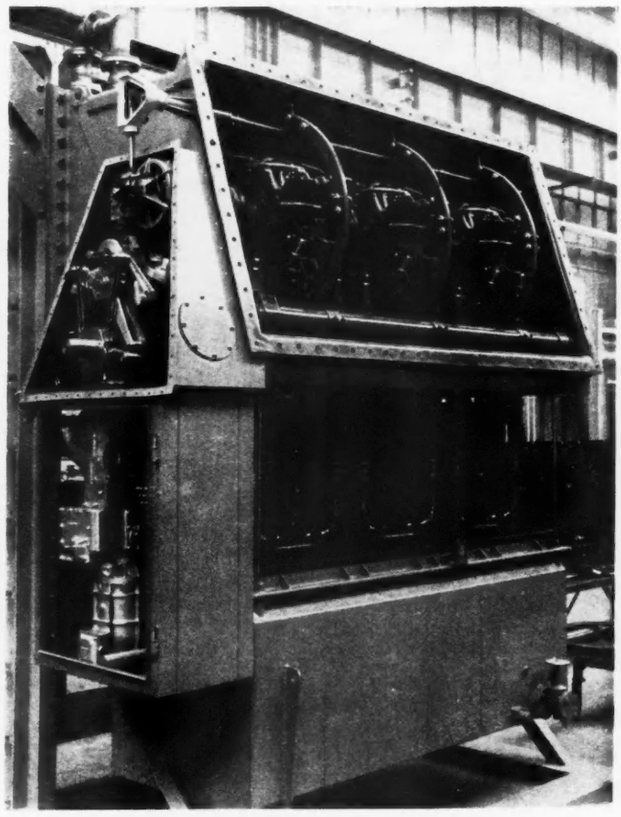
This tap-changer changes a tapping on load in half a cycle (0·06 seconds) at loads up to 200 per cent full load and can operate successfully at 300 per cent full load. It is designed to carry out 200,000 operations without requiring maintenance of the contacts or operating mechanism.

The equipment consists of a selector switch, a diverter switch and transition resistors, and operation is effected by a spring which is charged by a driving motor or, in emergency, by hand. In the selector switch there are ten fixed contacts and a changeover switch to give a maximum number of eighteen steps. Moulded epoxy resin supports give a high and stable insulation level, but most of the electrical stress is borne by the oil rather than the insulation structure. A special design of sliding stem bushing provides for expansion and contraction of the solid copper connections between the fixed contacts and the

transformer winding. The selector switch has been tested for 6,000,000 operations.

In the diverter switch the contact assembly is mounted on epoxy resin switchboards which are themselves fitted vertically in the lower tank. The vertical disposition of the switchboards reduces the risk of carbon deposits and consequent deterioration in insulation level. The crankshaft that drives the diverter switch contacts is above oil level and the "Tufnol" bearings carrying the shaft need no lubrication. To eliminate contact bounce (which causes premature contact wear and is difficult to avoid at the high speeds demanded by half-cycle operation), special attention has been given to the mass of the contacts and to the choice of spring pressure. The design is aimed at achieving rolling action between the contacts to ensure make and break without "wipe" and, therefore, with minimum frictional wear. Accordingly, contact life is determined solely by arcing, which is restricted to the arcing tips of special material.

An extension of the diverter switchboards carries the transition resistors. These resistors are made of ribbon wound non-inductively on ceramic supports to form a stable and open winding in which the possibility of carbon deposition is reduced. The resistors are designed to withstand a continuous series of fifty tap-changes at full load current for five minutes. Pairs of diverter switch contacts have been subjected to a series of operating tests at varying currents, i.e. 200,000 tap-changes at 700A and 400,000 tap changes at 400A, after which the current-carrying copper surfaces were unaffected by arcing. A series of 100,000 operations of the diverter switch at full load with 30kV maintained across one contact support caused no deterioration in electrical strength as a result of carbonisation and the deposit of carbon on the condenser bushings was relatively slight.



High-speed resistor on-load tap-changer designed for transformers on high voltage transmission systems up to 500kV

To avoid overloading the transition resistors, completion of each tap-change, after it has been initiated, is ensured by using a charged spring to drive the diverter switch crankshaft. There is a follow-through mechanism to complete the tap change at slow speed in the event of failure of the spring. The timing of energy release from the spring mechanism is accurately controlled by a new design of toggle-operated latch which is free from sliding-action wear and allows maximum torque to be developed at the instant of release. This spring mechanism is immersed in a separate chamber containing transformer oil.

The whole equipment is designed to comply with C.E.G.B. specifications and with European voltage test requirements, to withstand an impulse level of 350kV and a graded impulse level of 450kV. It is intended for operation in any climate; the selector and diverter switches can operate satisfactorily at temperature extremes of 90 deg. Cent. and −20 deg. Cent.

[Reply Card No. E6542]

Epoxy resin change-over switch moulding used in the high-speed resistor on-load tap-changer which is designed for transformers on high-voltage transmission systems

Explosive Forming of Metal Plates

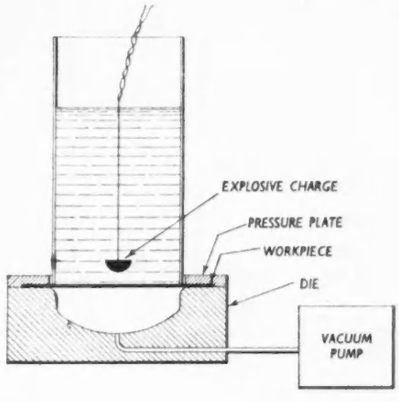
EXPERIMENTS have been carried out in the use of explosives for the high-speed forming of metal plates at the Crayford works of Vickers-Armstrongs (Engineers), Ltd. To keep the cost of the experiments within a reasonable amount the investigations were carried out on a one-twelfth scale model of the dome-end of a pressure vessel in 20 gauge bright mild steel plate, using "Tetryl" high explosive charges. The equipment with which satisfactory results were obtained is shown in the accompanying diagram. It consists of a mild steel die, a pressure plate, a vacuum pump and a thin sheet metal cylinder about 16in high.

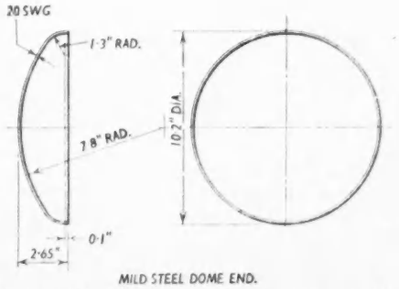
The cylinder was attached to the upper surface of the blank by waterproof adhesive tape and a thin film of grease was applied to the upper surface of the die to provide an airtight joint when the blank was placed upon it. The pressure plate was then fitted and the explosive charge suspended in the water-filled cylinder. Air was then evacuated from under the blank before the charge was detonated.

In the course of the experiments, charges varying in weight from 30 grains to 80 drams were used, and they were located at distances from 2½in to 8in above the centre of the blank. Charges of cylindrical and hemispherical shape were used. It appeared that the hemispherical charges gave the most satisfactory results, although the evidence was by no means conclusive.

It was found that, as with conventional press working, a pressure plate is essential to prevent wrinkling of the formed plate. Indifferent results were achieved with a vacuum of 24in of mercury, the residual trapped air in the die causing dents in the dome ends. It was finally established that very satisfactory results could be obtained by using hemispherical charges of 400 grains located 2½in above the centre of the blank, a vacuum of 29in of mercury, and ¼in entry radius on the die. The dome ends so produced varied little dimensionally, there being virtually no springback of the material, and the finish was very good. There was relatively little change in the thickness of the finished material, the maximum reduction being about 0·003in. This is attributed to the explosive force being applied almost instantaneously over the whole surface of the blank, whereas in conventional press work there is a concentration of stress at the nose of the punch.

As a result of these tests the firm states that, whilst explosive forming cannot compete with press working in large quantitity production of components of normal materials, it can be economically attractive if small quantities are required, more particularly if the components are to be of good finish and to close dimensions. Only a female die is required, and it is reported





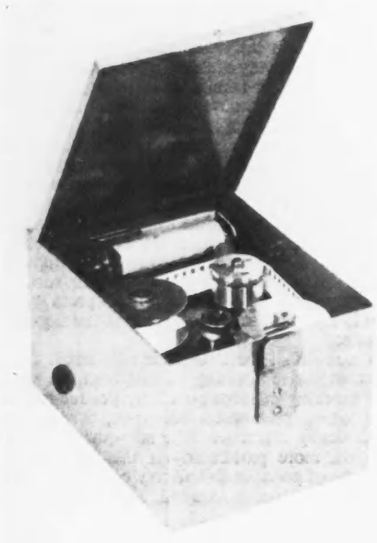
Experimental equipment for forming representative model of mild steel dome end for a pressure vessel

that good results have been obtained with wood, plastic, and concrete dies, depending on the number of components required, and the finish and dimensional requirements. Practical considerations apart, there would appear to be no limit to the size of plate which could be worked, and the regular shaping of components from 0·3125in thick mild steel has been reported.

SHORTER REPORTS *(Continued)*

Electrical Event Recorder

A RELIABLE record of the date and time at which electrical equipment is switched on and off, and of the period of time for which it operates, is provided by the Event Recorder and by an Hour Meter, manufactured by the special products department of A.E.I. Radio and Electronic Components Division, 155, Charing Cross Road, London, W.C.2. As it is independently driven the event recorder (illustrated here),



Event recorder to provide reliable record of date and time at which electrical equipment is in use. It is independent of mains supply

can be used to record the time during which a machine is shut down through mains failure, and is applicable in machine time study and process control timing.

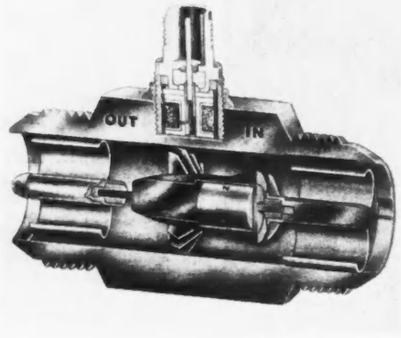
It has a 15-day clockwork movement, with an accuracy of ±5 minutes throughout the 15-day cycle. This movement drives, via a sprocket, a recording chart at a speed of 1in per hour. The chart, 31ft long and $\frac{3}{8}$in wide, is copper sensitive Chromograph paper, perforated on one edge for driving. It is calibrated according to the service required by the user. To ensure ease of paper flow from one spool to the other, a guide device is incorporated. The spools are also designed to facilitate quick replacement of the recording chart. The stylus is of durable copper, and is mounted on the armature of a solenoid actuated when the supply to equipment under examination is switched on. When the solenoid is operated the stylus is brought into contact with the chart. The solenoid normally operates at 200V, d.c., 5mA, but solenoids for any supply from 50V to 250V inclusive, a.c. or d.c., can be supplied. An additional solenoid and stylus can be incorporated to convert the instrument to a twin channel recorder. If required, extra channels and speeds other than the standard 1in per hour can be supplied. A sapphire stylus is available and the unit can also be supplied fitted with a synchronous motor. The recorder is available as a self-contained unit in a hammer-grey finish metal case with detachable, spring-loaded, self-latching lid (for which a lock is available), or without its case, so that it can be incorporated in other equipment. With case, the unit measures 5$\frac{1}{2}$in by 4$\frac{1}{2}$in by 4in, and weighs 3 lb 12 oz.

The hour meter is used for the summation of running time of equipment. It consists of a self-starting synchronous motor operating a four- or five-digit counter, whose cyclometer-type dial gives a clearly read indication up to 9,999 or 99,999 hours before resetting to zero. The hour meter is connected across the supply to the equipment whose total operating time it is required to record. The unit is available for operation from 200V/250V, 50 c/s a.c. supply and can be supplied for other mains voltages and frequencies at slight extra cost. The case (in hammer-grey finish), designed for flush or surface mounting, basically measures 2$\frac{1}{2}$in by 2$\frac{1}{2}$in by 2$\frac{1}{2}$in, with a 3in by 3in front flange on the flush mounting unit.

[Reply Card No. E6561]

Turbine Flowmeter

A SERIES of demonstrations was given in the development laboratory of de Havilland Propellers, Ltd., Hatfield, Herts, on April 5, to show the principles and applications of the de Havilland "Pottermeter." This turbine flowmeter is used by most of the missile manufacturers in the U.S.A. and has many general industrial uses. De Havilland Propellers, Ltd., is responsible for the manufacture of the device in this country and for sales outside the Americas, Japan, and parts of the Middle East. As seen in the accompanying cutaway view, the sensing element contains a turbine rotor carrying a small permanent magnet polarised at right angles to the axis. As the rotor revolves, an alternating



Cutaway view of flowmeter showing rotor magnet and pick-up coil

current is induced in the stationary pick-up coil. This sine wave output may be amplified, shaped into square-wave pulses and counted. Calibration charts are supplied showing how many revolutions correspond to a desired unit of volume. By connecting the output to a frequency meter, rates of flow may be measured.

A feature of the "Pottermeter" is that it has no thrust bearing, the armature merely floating in guides. At the inlet end a deflector cone forces the fluid into a comparatively narrow passage, with a consequent reduction in pressure at this end of the rotor. Since the other end is subject to a higher pressure because of the venturi shape of the tube, the rotor tends to move "upstream," but in so doing it encounters the wash of the incoming fluid and so runs in a state of balance. The unit can therefore be operated in any position.

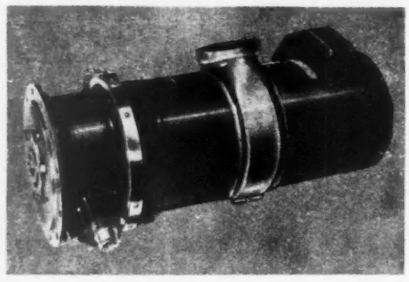
Several demonstrations were arranged to show applications of the various items of electronic counting equipment and transducers available for use with the "Pottermeter." These include pulse counters with readout in revolutions or direct in gallons, pounds, or other units; batch counters, rate-of-flow indicators, and a digital densimeter enabling the direct-reading counter to show the weights of fluids of different specific gravities. The batch counter was seen operating in a control circuit which accurately arrested the filling of a vessel when the fluid reached the rim. These electronic accessories are transistorised and built up with printed circuit boards. A further application showed two "Pottermeters" in a process control system for blending fluids in desired proportions. They may be used for the control of mixtures by volume and weight in any proportions. This is typical of the uses of the device in the food industry, for which a model has been designed capable of being taken down for cleaning and reassembled by unskilled personnel without special tools.

The "Pottermeter" is made in sizes from $\frac{1}{8}$in to 22in, covering flow rates from $^1/_{10}$ gallon to 30,000 gallons per minute. It can be used with any liquid irrespective of lubricating or non-lubricating properties, or for gas flow measurements, and has a temperature range from −455 deg. to +1500 deg. Fah.

[Reply Card No. E6562]

Aircraft Constant-Speed Alternators

UNDER a licence agreement with Precision Mécanique Labinal in Paris, the Plessey Company, Ltd., Ilford, Essex, is starting to manufacture a range of aircraft constant-speed alternators. The 4kVA unit in this range (illustrated



4kVA aircraft constant-speed alternator unit designed to operate at altitudes of up to 55,000ft with forced draught cooling and to withstand accelerations up to 15 *g* in all directions

here) is designed to operate at altitudes of up to 55,000ft with forced draught cooling and will withstand accelerations up to 15 *g* in all directions. It has been operating successfully in French fighter aircraft for some years, and a French type-approval has been obtained. At present machines have been developed over the power range 4–19kVA, and units of up to 35kVA are being investigated.

The machines will embody the Labamatic principle of constant frequency control, which is based on electromagnetic coupling incorporated in the drive to the alternator shaft. Constant rotor speed is maintained by controlling coupling slip by means of an amplifier system and a frequency sensitive network. The electromagnetic coupling may be employed in conjunction with a variety of simple gear drive arrangements. To improve efficiency an automatic two-speed gearbox can be included in the drive; with this addition an engine speed range of 3$\frac{1}{2}$–1 can be obtained.

The first machine to go into production is a 4kVA, 208V, 400 c/s alternator having a power factor of 1·0 to 0·75 lagging. When this alternator is coupled to a drive ranging from 2900–8000 r.p.m., the output voltage is maintained constant to within ±2·5 per cent and the frequency to within ±2 per cent. Overspeed is permitted up to 9000 r.p.m. for short periods. An electrically-operated automatic two-speed gearbox is fitted as standard equipment on the 4kVA model. Magnetic amplifier circuits are used throughout the control system and protection is provided against under-voltage, over-voltage, under-frequency and earth faults. The total weight of the machine, together with frequency regulator, voltage regulator and protection unit, is 72 lb. In an alternative form without automatic two-speed gearbox, the machine is suitable for drive shaft speeds of from 4700–8000 r.p.m., and the total weight is then reduced to 64 lb.

[Reply Card No. E6563]

4MeV Linear Accelerator for Radiographic Examination of Welds

A DEVELOPMENT contract for a mobile linear accelerator designed to take X-ray photographs of the welds in the pressure vessel of a nuclear power station has been placed by the U.K. Atomic Energy Authority with Mullard Equipment, Ltd., Torrington Place, London, W.C.2. The machine is expected to be operational towards the end of the year. The contract results from investigations, commissioned by the Authority, into the suitability of such machines for making radiographic inspections of welds in thick materials.

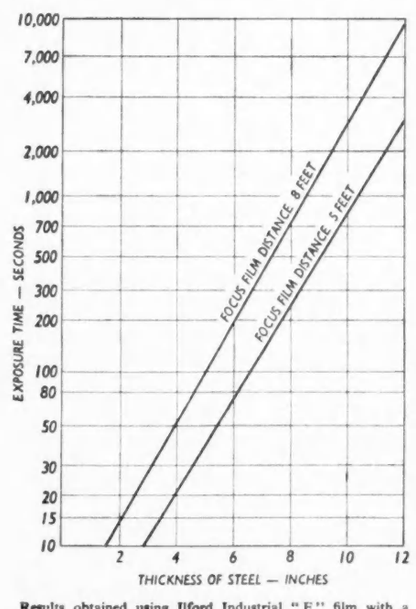
The accelerator will have an energy rating of 4,300,000 electron volts and will give an X-ray output of over 600 röntgens a minute in air at 1m focus film distance. Because of its high energy rating it will make possible faster radiographs through greater thicknesses of material than is practicable with conventional X-ray or isotope sources. With an exposure time of less than 100 seconds, using Ilford industrial "F" film, the accelerator will produce a high definition radiograph of a steel specimen 6in thick ; with faster film the exposure time for this thickness would be reduced to under 60 seconds. A graph showing exposure times for different thicknesses of steel is reproduced here.

The accelerator is specially designed for use on site during the building of a nuclear power station with a minimum of disturbance to the constructional work. It is easily controllable and has comprehensive positioning facilities for easy and accurate location on the specimen. An earlier but similar accelerator equipment was installed in a Government establishment

The accelerator unit will be mounted in a trunnion fork assembly, and will weigh approximately 1·3 tons and measure about 8ft overall length. Its power supply and control units will be housed in a transportable cabin which may be placed up to 250ft away from the accelerator unit. Besides giving greater flexibility for on-site operation, this arrangement will enable the operators to keep well clear of radiation from the machine. The machine will be developed from the standard 4·3MeV accelerators which have been marketed by the company for a number of years for medical, industrial research and radiographic applications. The X-ray output of the accelerator is greater than 600 röntgens a minute measured in air at 1m distance from the target, with the beam collimated to give a circular field 30cm in diameter. But since the X-ray output is so large, increased focus film distances can be employed to provide larger fields. An adjustable lead iris enables the field size to be reduced to 30cm by 5cm at 1m focus film distance.

With a source diameter of approximately 2mm the resulting X-ray photographs show a sensitivity better than 0·5 per cent on steel specimens between 4in and 8in thick and 0·8 per cent with thicknesses of about 2in. These results are obtained using standard D.I.N. wire penetrameters, the film (Ilford industrial "F") being exposed to give a density of 2·5. The r.f. power source is a magnetron valve driven by 5 megawatt power pulses from the modulator. The pulse duration is 2 microseconds and the pulse repetition frequency 500 a second.

[Reply Card No. E6571]

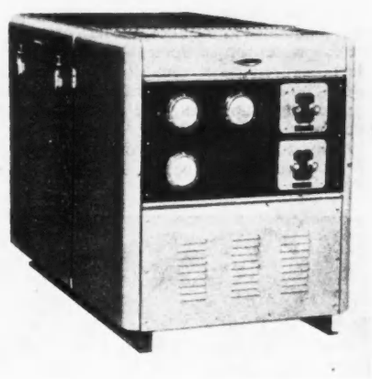


Results obtained using Ilford Industrial "F" film with a density of 2·5. For a density of 2·0 the exposure times shown would be multiplied by 0·8, and when using Industrial "C" film they should be multiplied by 0·7.

Exposure times required for various thicknesses of steel when the accelerator is operating at 600 röntgens a minute at 1m

Pump for Liquefied Gases

Two new models of pumps for liquefied gases, now being made by the Distillers Company, Ltd., Great Burgh, Epsom, Surrey, have respective capacities of 100 and 200 gallons an hour at a pressure of 1000 lb per square inch. These pumps consist essentially of a double-acting diaphragm head actuated by a hydraulic system, enabling any pumping rate from zero to maximum output. The diaphragm heads are maintained at the required low temperature in a refrigerated cell.



Pump for liquefied gases with a capacity of 100 g.p.h. at 1000 lb per square inch

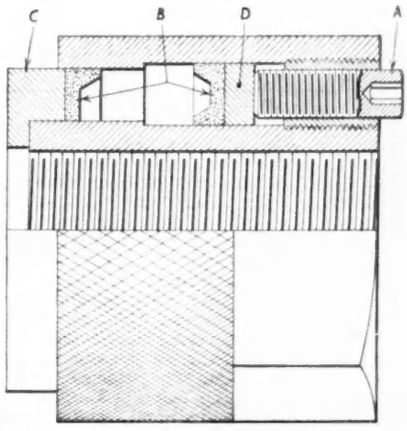
One of the new pumping sets can be seen in the illustration and these sets, unlike earlier models of smaller capacity made by the firm, have the complete diaphragm head and hydraulic actuating equipment enclosed within a single cabinet. The instrument control panel forms an integral part of the cabinet front. The refrigerating equipment, which is normally supplied by Frigidair, forms a separate unit outside the pump cabinet, as its capacity and temperature characteristics depend upon the temperature at which the liquefied gas has to be pumped.

[Reply Card No. E6572]

Hydraulic Nut

A "HYDRAULIC" nut developed by Euco Tools, Ltd., 44, London Road, Kingston, Surrey, is designed to enable effective tightening with a greater pressure and using less effort than in the case of a spanner-tightened nut and at the same time to eliminate the torsional strains imposed when tightening a nut in the conventional way. The construction of one of these hydraulic nuts can be seen in the drawing we reproduce.

The nut has a high-tensile steel body with an annular recess bored in its front face. This recess communicates with a bore extending through to the rear face, the bore being threaded to receive a reducing bush which accommodates a socket head pressure screw *A*. The recess and the bore are filled with a special compound and its ends fitted with annular seals *B*. A thrust ring *C* in the recess bears against the front seal and a pressure pad *D* which bears against the rear seal transmits the pressure applied by the screw. When fitting the nut it is screwed up hand-tight and its full gripping pressure applied by turning the pressure screw inwards with an Allen key.



Construction of hydraulic nut

In tests carried out by the maker a 1in B.S.F. hydraulic nut was screwed on to a test rig to impart an initial pressure of ½ ton per square inch. When the pressure screw was then turned by finger and thumb the applied pressure on a load cell is stated to have increased to 4 tons per square inch. The firm is now producing these nuts in all sizes from ¾in to 2in diameter with Whitworth, American, Unified and Metric threads.

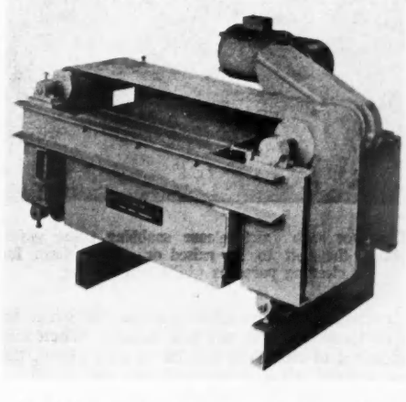
[Reply Card No. E6573]

Magnetic Separators

A NEW range of high intensity electro-magnetic separators for the extraction of feebly magnetic particles from silica sands and like materials which are travelling on existing conveyors has been developed by Industrial Magnets, Ltd., Station Road, Acocks Green, Birmingham, 27. The separator as can be seen in the illustration, is a self-contained unit, made in a series of sizes to cover conveyors from 12in to 48in wide, and only requires supporting from stringers on an existing installation.

The separator operates on a cross belt principle, and its framework carries a high permeability steel magnet with a totally enclosed high conductivity copper magnetising coil. The cross belt, passing along the magnet poles immediately over the main conveyor burden, extracts magnetic particles from material being processed and provides automatic discharge. These separators can readily be incorporated into existing conveyor systems and, if required, a number can be installed over the same conveyor. Each unit in a grouped installation can have an individual adjustment for the working gap, thereby enabling particles of different magnetic susceptibility to be extracted. Rheostatic control for magnetic intensity can also be arranged. Each separator is supplied complete with a totally enclosed geared motor and chain drive.

[Reply Card No. E6574]



Cross belt magnetic separator with motor and drive for the extraction of feebly magnetic particles on conveyors

SHORTER REPORTS *(Continued)*

Grinding Machine

A GRINDING machine now being made by Rudkin and Riley, Ltd., Aylestone, Leicester, has an internal grinding range from 0·04in to 3½in and can be fitted with an external grinding attachment for work up to 3in diameter between 7in centres. The machine has a cabinet base with a vee bed on which the grinding carriage is carried on ball bearings. This carriage is traversed by a ½ h.p. motor and its length of automatic grinding feed is set by a cam up to a maximum stroke of 4in. The grinding spindle is belt-driven from a ½ h.p. motor at 38,000 r.p.m. and alternative air-driven or high-frequency spindles can be fitted for higher speeds.

The headstock takes work chucks up to 6in capacity and two spindle speeds of 500 or 1000 r.p.m. are available. It is mounted on a slide giving a cross traverse of 4⅛in by handwheel with reference to a scale graduated in 0·0001in increments. The head is carried on a swivel mounting on its slide and can be swung through 60 deg. in either direction. Coolant is delivered to the work during grinding through the hollow spindle of the headstock.

For external grinding purposes the grinding carriage housing is swung round through 180 deg., thereby off-setting the grinding spindle by 2½in. When external grinding between centres is called for, a slide bar at the rear, which takes the diamond truing tool, is used to carry the tail centre. A radius grinding attachment, available with a machine not arranged for adaptation for external grinding, is used in conjunction with a template and grinds radii down to ⅛in.

[Reply Card No. E6581]

Easily Cleaned Belt Conveyor

A BELT conveyor made by Farrow and Jackson, Ltd., 41/2, Prescot Street, London, E.1, is suitable for use on filling or packing systems handling sticky and similar products which cause belt clogging and necessitate frequent cleaning of the belt. This conveyor is designed to permit easy cleaning of a belt and its skid plates without need for stopping the main drive of the line. Incorporated at the drive end of the conveyor

Conveyor with quick-release snubbing roller which allows the belt to be raised or pulled down for cleaning purposes whilst still running

structure there is a snubbing roller over which an additional length of the belt passes. When it is required to clean the belt or its skid plates, the movement of a handle pivots the snubbing roller frame to make the additional length of belt available on the conveyor line. With this extra length of belt the main run can be lifted clear on the carrying side or pulled downwards on the return side for cleaning the skid plates and belt surfaces.

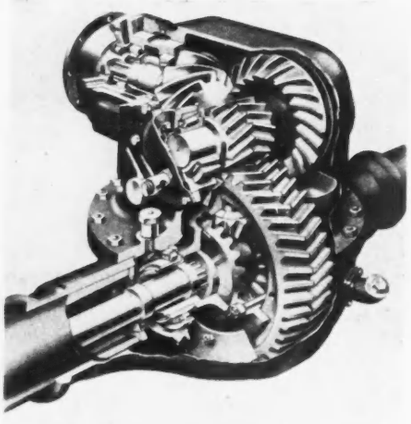
A typical conveyor of this design, illustrated, shows the belt being raised from its plates for cleaning and the snubbing roller can be seen in its free position below. This particular conveyor has a double-faced white P.V.C. belt running over raised skid plates ⅛in thick. A pivoted guard rail system over the belt is made up of ½in diameter stainless steel bars and its sections can be swung clear of the belt for cleaning purposes.

[Reply Card No. E6582]

Double-Reduction Axle

A DOUBLE-REDUCTION axle has now been introduced by Leyland Motors, Ltd., and is recommended for heavy and super-heavy duty single-drive vehicles, such as the "Beaver" and the trailing axle "Octopus." It uses a hypoid bevel for the first reduction and therefore cannot form part of a direct coupled bogey. In contrast to the axle recently introduced for the lighter vehicles of the Leyland Group, which has the final reductions in the hubs, the new axle imposes the full wheel torque upon the differential. The secondary reduction uses double-helical gears, so that no side thrust is generated in it, and hence the bearings supporting the differential experience journal loads only.

A distinctive feature of the axle is the system of oil circulation, which is designed to ensure



The hypoid bevel axle with double helical final drive : notice that the differential is not located along its axis by the bearings

that all working parts receive a supply of oil by the time the road wheels have made half a revolution. Oil is picked up from the sump by a disc beside the helical wheel and picked off by a collector which feeds not only the nearside helical pinion bearing and the hypoid pinion bearings but also a trough on the offside of the intermediate shaft. Into this trough dip both the hypoid wheel and another disc which picks up oil for the bearing taking the thrust on the hypoid wheel. This trough cannot be emptied without dismantling the axle (or running it without oil in the sump).

[Reply Card No. E6583]

Transition to Jet Lift

THE Short S.C.1 vertical take-off and landing research aircraft last week performed transitions from powered to aerodynamic lift and back. This machine is, it will be recalled, the one example of a jet-propelled flat-riser which uses separate lifting and thrusting engines, but the lift engines can be pivoted to provide acceleration along the longitudinal axis.

Bright Platinum Plating

To overcome difficulties in platinum plating with conventional plating baths, Johnson Matthey and Co., Ltd., has introduced a stable platinum plating solution which is stated to give bright, heavy and coherent deposits. This plating solution is based on the complex sulphato-dinitrito-platinous acid $H_2Pt(NO_2)_2SO_4$. The bath is acidic and may therefore be used successfully on electrical components and printed circuits, and platinum from the solution can be deposited directly on to copper, brass, silver, nickel, aluminium and titanium. For deposition on tin, zinc, cadmium or steel, an undercoat of silver or nickel is necessary. Electrographic tests have shown no evidence of porosity in these platinum deposits up to 0·001in thick on polished copper. Above this thickness some slight evidence of cracking may be observed.

It is stated by the makers that the character of the deposits remains unchanged in the temperature range 30 deg. to 70 deg. Cent., but the recommended operating temperature is 50 deg. Cent. At a current density of 5A per square foot, and at 50 deg. Cent., the deposition rate is 0·0001in in two hours. At this rate very accurate control can be exercised over the amount of metal deposited, and for the majority of applications these conditions represent the best compromise of efficiency with economy.

[Reply Card No. E6584]

Manufacture of Doxford Crankshafts

ON March 25, before the North East Coast Institution of Engineers and Shipbuilders, Mr. R. Atkinson, B.Sc., read a paper entitled "Manufacture of Doxford Crankshafts." The paper deals with the history and development of the shaft from the original Doxford opposed-piston oil engine and then goes on to discuss the materials used, methods of heat treatment and the preparation of the parts for shrinking. A description is given of the shrinking process as well as the final machining, followed by notes on assembly. Appendices deal with shaft couplings and shrink fits while line drawings, together with illustrations, indicate various stages in design and manufacture.

S.B.A.C Exhibition, 1960

THE twenty-first Flying Display and Exhibition of the Society of British Aircraft Constructors will be held at Farnborough from September 5 to 11, 1960, the public being admitted on the Friday, Saturday and Sunday.

Launches and Trial Trips

BRITISH CURLEW, oil tanker ; built by Alexander Stephen and Sons, Ltd., for B.P. Tanker Company, Ltd.; length between perpendiculars 495ft, breadth moulded 69ft, depth moulded 37ft, deadweight 14,000 tons on 27ft 6in service draught and 15,500 tons on 29ft 4½in summer draught, service speed 14½ knots ; twenty-seven cargo oil tanks, four 500 tons per hour cargo oil pumps ; Stephen-Sulzer 7 R.S.A.D. 76 single-acting, two-stroke, turbo-charged diesel engine, 8750 maximum brake horsepower at 115 r.p.m. with mean effective pressure of 99 lb per square inch, 7750 service brake horsepower. Launch, January 12.

PEARLEAF, oil tanker ; built by Blythswood Shipbuilding Company, Ltd., for Jacobs and Partners, Ltd.; length between perpendiculars 535ft, breadth 71ft 8in, depth moulded 39ft, draught 30ft 0½in, deadweight 18,045 tons, trial speed 15¾ knots ; twenty-seven cargo oil tanks, two pump rooms, four 500 tons per hour cargo pumps, one 100 tons per hour stripping pump, one 250 tons per hour special cargo oil pump ; two 300kW diesel-driven generators, one 100kW steam-driven generator ; Rowan-Doxford oil engine, six cylinders, 8800 maximum brake horsepower. Trial, January 27.

INDUSTRIAL NEWS

Transport Commission's Advisory Group

On Wednesday of last week, the Minister of Transport, Mr. Marples, announced, in the House of Commons, the appointment of an " advisory group " for the British Transport Commission. The chairman of this group is to be Sir Ivan Stedeford, chairman and managing director of Tube Investments, Ltd., the other members being Mr. C. F. Kearton, joint managing director of Courtaulds, Ltd., Dr. R. Beeching, technical director of Imperial Chemical Industries, Ltd., and Mr. H. A. Benson, partner in Cooper Brothers, chartered accountants. The Treasury and the Ministry of Transport are also to be represented. The task of the group, the Minister stated, would be to examine the structure, finance and working of the organisations at present controlled by the British Transport Commission and to advise him and the Commission, as a matter of urgency, how effect could best be given to the Government's intentions as indicated in the Prime Minister's statement on March 10. It will be recalled that in that statement the Prime Minister referred to the appointment of a " special planning board " to examine the structure, finance and working of the organisations at present controlled by the British Transport Commission.

In making his announcement last week, the Minister of Transport said that the " advisory body " was not necessarily to give expert advice. It would be considering expert advice which was given to it. It would be in close touch with the British Transport Commission and the unions and they and anyone else might make any recommendations they wished. The body, he added, would not be executive but purely advisory. As we go to press, the matter is being debated in the House of Commons.

Dry Docks and the Budget

Mr. J. O. M. Fisher, chairman of the Dry Dock Owners and Repairers Central Council, commenting on the Budget, said last week that the omission of any concession to meet the request for an increased investment allowance to 40 per cent, the same as that accorded to shipowners, and for an increase from 2 to 5 per cent in the annual allowance, put forward by the dry dock owners, was a severe disappointment. It was disappointing to an industry faced with strong competition from countries where much more favourable treatment was given to investment in dry docks. Dry docks, he continued, were " one-purpose " assets which represented considerable capital investment and which gave very little return for a number of years. They were essential to the economy of the industry and it was regrettable, Mr. Fisher commented, that although the situation had been impressed upon the Government, a Government which professed concern for the maritime industries, the claims for better taxation treatment had been ignored.

Institute of the Motor Industry

At the annual dinner of the Institute of the Motor Industry (Incorporated) on Thursday of last week, the fortieth anniversary of the Institute was celebrated ; the toast of " The Institute " being proposed by Mr. K. P. Thompson, M.P., Parliamentary Secretary to the Ministry of Education. The response to the toast was made by the president, Mr. Stanley S. Dawes, who held that office in 1943–45 and continuously since 1950, and included the announcement that there had now been instituted at the Loughborough College of Further Education a three-year full-time course, leading to a Diploma of the Motor Industry, for candidates with " O " level G.C.E. education and at least six months' experience in the industry. (The four-year residential Diploma course for " A " level candidates takes place at the College of Advanced Technology, Loughborough.) Mr. Dawes reaffirmed his conviction that only the education of members of the industry to enable them to develop to the full their individual capabilities could allow the industry to make its proper contribution to the community as a whole. He added a plea for liberality in education :

" It is abundantly clear that as each industry becomes more mechanised and scientifically administered, so the need for fully trained personnel in specialised operations and techniques is accentuated, but, while the importance of technical vocational training cannot be overstressed for the efficient running of the productive machine, it is now realised that there is greater productivity, less dissatisfaction, more happiness and prosperity in industrial organisations where personnel are trained on a broader basis than mere operational pursuits and are given an insight into the physical, industrial, financial and administrative structure of the organisation of which they are an important part and are allowed to see the juxtaposition of their own jobs with those of management and executive control, and the value of their contribution to the society in which they live." It was announced that the president-elect is the Viscount Addison, who, in common with his predecessor, was trained as a mechanical engineer.

Steel Prices

The Iron and Steel Board has announced some revision of the maximum prices of a limited range of steel products. The products concerned are stainless and alloy steels, cold rolled carbon steel strip and certain specifications of non-alloy bright steel bars and heavy rails. The Board says that these changes, some of them upward and some downward, represent corrections in the price structure and that, on balance, they have no appreciable effect on the general level of steel prices.

The most significant changes are in stainless steel, the price schedule for which has been extensively recast in the light of experience gained in costs at modern plants. Broadly speaking, the maximum prices of stainless steel bars have been increased, the overall increase being of the order of £13 a ton. The maximum prices of stainless steel flat products have generally been reduced, the estimated overall decrease being £9 a ton for plates and £13 a ton for cold rolled strip. These changes do not apply, however, to all sizes and qualities. The other price changes, which are much less marked either way, relate to alloy steels and cold rolled carbon steel strip. Furthermore, in the case of non-alloy bright bars, the " extras " for annealing or normalising and cutting to length have been revised as have also the " extras " for special lengths of heavy rails. All the changes became effective as from last Monday, April 11.

Apprentice Training

The Minister of Labour, Mr. Edward Heath, announced in Parliament on Monday that it was proposed to set up a small number of classes in Government training centres to provide first year apprenticeship training. This training, he said, would be given only to boys accepted as apprentices by firms, and preference would be given to boys from firms which had hitherto found it impracticable to undertake apprentice training or to increase their present number of apprentices. No charge would be made for the training provided, but the Minister explained that employers taking part in the scheme would be required to give an undertaking to pay the wages of apprentices during the year and to continue the boys' training afterwards under the normal industrial arrangements. The usual provision for day release would apply during the year. The Minister added that the scheme had been approved by the British Employers' Confederation and the Trades Union Congress. The establishment of classes in engineering had been agreed by employers and trade unions in that industry and it was intended to extend the scheme to other industries.

Following the Minister's announcement, it has been stated that the first training places will be available early this summer at eight Government training centres, namely, Aintree, Birmingham, Bristol, Cardiff, Hillington, Leeds, Letchworth and Long Eaton. It is expected that classes will be established at other centres, probably Enfield, Leicester, Perivale, Slough and Waddon, later this year, making a total of about 300 training places. Training will cover a systematic syllabus similar to that followed during the first year by firms with good apprenticeship training schemes.

United Kingdom Exports

The latest analysis of the overseas trade figures made by the Board of Trade shows that the increase in total exports of United Kingdom products in the three months December to February last was 16 per cent, compared with a year previously. Half the increase in the last three months was accounted for by engineering products. Machinery exports increased by 18 per cent (£12,000,000 a month). Exports of agricultural and tracklaying tractors increased by 41 per cent and there were also marked increases in exports of office machinery, machine tools, excavating machinery and electric wires and cables. Exports of cars increased by 45 per cent or £7,000,000 a month. The increase in exports of commercial vehicles and chassis, which began last autumn, was maintained, exports increasing by 27 per cent. Exports of ships and boats, aircraft and railway vehicles were, however, less than a year earlier.

PERSONAL AND BUSINESS

Appointments

MR. J. W. RINGROSE has been appointed chief applications engineer of Semiconductors, Ltd.

MR. W. NEWLAND WILLIAMS has been appointed sales manager of Dunedin Engineering Company, Ltd.

MR. L. C. LEBAR has joined Electronic Machine Company, Ltd., as project and technical sales engineer.

MR. H. MCGLYN has been appointed quality control engineer at the Brighton factory of West Instrument, Ltd.

MR. D. E. A. MILLER-WILLIAMS has been appointed public relations officer for the motor-car division of Rolls-Royce, Ltd.

SIR DONALD FORSYTH ANDERSON has joined the board of directors of the British India Steam Navigation Company, Ltd.

MR. GEORGE BEEBEE has been appointed comptroller of the British divisions of the Yale and Towne Manufacturing Company.

MR. C. R. NEWTON, chief accountant of Cockburns, Ltd., has been appointed a director of the subsidiary company, Cockburns (Springs), Ltd.

MR. ARNOLD W. LEE, managing director of Norton Grinding Wheel Company, Ltd., has been appointed to the board of directors of Behr-Manning, Ltd.

BAILEY METERS AND CONTROLS, Ltd., has announced the appointment of Mr. V. A. Plumley as manager of the Bailey meter division of Steam and Mining Equipment (Pty.), Ltd.

BRYCE BERGER, Ltd., has announced the appointment of Mr. Morris W. Timberlake as northern area sales engineer in succession to Mr. J. R. Vallance who has left the company's service.

MARRYAT AND SCOTT, Ltd., announces that its southern branch representative, Mr. H. L. Nathan, has retired and it has appointed Mr. J. A. Conyers to manage the area from regional headquarters, 34, Chesham Road, Brighton, 7.

AITON AND CO., Ltd., states that Mr. R. H. Weston has been appointed area manager for Scotland and has been succeeded as works manager at Derby by Mr. K. H. Ewen. Mr. J. M. G. Lochhead has been appointed assistant marine representative.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that Mr. C. G. Hickling, A.M.I.E.E., has been appointed manager of the Middlesbrough branch in succession to Mr. G. W. Wheaton, who has taken up an appointment at the Prescot Works.

GRIFFIN AND GEORGE (RESEARCH AND DEVELOPMENT), Ltd., states that Dr. A. J. P. Martin is to retire as a director of the company, but will continue to be retained as a consultant. He is succeeded as director of research by Mr. R. C. Palmer, his present deputy.

DR. D. H. FOLLETT has been appointed to be director of the Science Museum in succession to Dr. T. C. S. Morrison-Scott. He will be succeeded as keeper of the department of electrical engineering and communications in the Science Museum by Mr. D. Chilton.

NORMALAIR, Ltd., a wholly-owned subsidiary of Westland Aircraft, Ltd., announces the following appointments: Mr. E. C. Wheeldon, chairman; Mr. D. C. Collins, managing director; Dr. E. W. Still, assistant managing director; Mr. T. Bretherton, secretary.

THE BRITISH STANDARDS INSTITUTION announces that Professor R. H. Matthew has been appointed chairman of the building divisional council in succession to Mr. Paul Gilbert. Mr. H. N. Pemberton has been appointed chairman of the council for codes of practice, in succession to the late Mr. A. C. Hartley.

CONCRETE, Ltd., announces that Mr. Edward Bush has retired from the position of sales manager due to ill-health, but will retain an active connection with the company as a sales consultant. Mr. Peter Schryver, sales director of Concrete (Southern), Ltd., will join the main board of Concrete Ltd., as sales director for the company.

TILTMAN LANGLEY, Ltd., announces that Dr Edmund T. Price, of San Diego, California, has been appointed managing director. Mr. L. A. Wingfield has been re-appointed as chairman of the company, and Mr. Leslie D. Neeves as secretary. Other appointments to the board of directors include Mr. Marcus Langley, Mr. A. Kenneth Clyde, and Mr. W. E. Patrick Johnson.

THE DISTILLERS COMPANY, Ltd., announces that Mr. G. F. Ashford has been appointed deputy chairman of the chemical group. Mr. J. M. Rimington, managing director of the chemical division, has retired for reasons of health and has been succeeded by Mr. J. H. Dunn. Mr. J. S. Hunter has succeeded Mr. Dunn as assistant managing director (commercial) of the chemical division.

CENTRAL ELECTRICITY GENERATING BOARD announces that following the appointment of Mr. H. C. Spear as chief personnel officer, the personnel department has been reorganised and the following appointments have been made: Mr. I. G. Ellis becomes assistant chief personnel officer; Mr. N. Berryman becomes personnel officer (headquarters); Mr. E. D. Selby Lowndes, A.M.I.E.E., becomes personnel officer (policy); and Mr. J. F. G. Bland becomes assistant education and training officer (policy).

WESTLAND AIRCRAFT, Ltd., announces the following organisation changes consequential upon the recent acquisition of other companies and their integration into a single specialist helicopter group. Sir Reginald Verdon Smith and Mr. C. N. Chichester Smith have been elected to the board. Mr. E. C. Wheeldon, managing director, has also been appointed a joint deputy chairman. Mr. D. L. Hollis Williams and Mr. W. Oppenheimer have been appointed assistant managing directors. Mr. A. R. B. Hobbs has been appointed secretary. The following have been appointed special directors: Yeovil division, Mr. E. J. Boulger, group contracts manager; Mr. O. L. L. Fitzwilliams, chief engineer; Mr. E. J. Frost, works manager; Mr. C. T. Jones, group insurance manager; Mr. H. J. Penrose, group sales manager. Saunders-Roe division, Mr. M. W. C. Gordon, general manager; Bristol Division, Mr. R. Hafner, chief engineer; Fairey Division, Mr. H. W. D. Winkworth, general manager; Dr. G. S. Hislop, chief engineer.

Business Announcements

BRITISH ROPES, Ltd., has completed negotiations with the New Zealand Government to set up a wire ropery in Auckland.

MR. C. E. PERRY, chief design engineer of Evershed and Vignoles, Ltd., retired on March 31, after forty-eight years of continuous service with the company.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, announces that it has acquired the whole issued share capital of the County Water Softener Company, Ltd., Purley, Surrey.

MR. P. D. NEWTON, A.M.I.C.E., has been taken into partnership by the consulting engineers, Messrs. S. Cussons and Partners, 112, Borough Road, Middlesbrough.

MERZ AND MCLELLAN announce that Mr. Frederick Cavendish Winfield has retired from the partnership, but has agreed to continue his association with the firm as a consultant.

MR. J. LAWRENCE, general manager of The General Electric Company, Ltd., installation equipment division, retired on March 31, after thirty-nine years' service with the company.

STEDALL MACHINE TOOL COMPANY, 192/208, Pentonville Road, King's Cross, London, N.1, states that it has been appointed sole distributor in the United Kingdom for the new Schou automotive machine equipment.

THE FAIREY COMPANY, Ltd., announces that Mr. R. L. Lickley, M.I.Mech.E., has resigned from the board of the company with effect from March 31, and has relinquished his appointments with the subsidiary companies of the Fairey Group.

SIR WILLIS JACKSON, president of the Institution of Electrical Engineers, and MR. W. K. BRASHER, secretary of the Institution, were sponsored by the British Council to hold discussions in Poland on the training of electrical engineers earlier this month.

POWELL DUFFRYN, Ltd., Boundary House, 7–17, Jewry Street, London, E.C.3, states that it has acquired the whole of the share capital of Kelmac, Ltd. The company owns a limestone quarry at Nether Kellet and produces limestone products.

MR. R. H. PHILIP, director and company secretary to Armstrong Whitworth (Metal Industries), Ltd., has left by air for Australia to complete administrative arrangements following the opening of a subsidiary in Australia, Armstrong Whitworth (Australia) Pty., Ltd.

ELECTRICAL RESISTANCE FURNACE COMPANY, Ltd., announces that it is now manufacturing and marketing in this country quenching oils containing Quenzine—a formulation of wetting oils and other ingredients developed in the U.S.A. by Aldridge Industrial Oils, Inc.

THE PARSONS ENGINEERING COMPANY, Ltd., Southampton, announces the acquisition of a sole and exclusive manufacturing and selling licence in Great Britain and the British Commonwealth for Renk oil-operated marine reduction gears, designed by Zahnraderfabrik Renk Aktiengesellschaft of Augsburg, Germany.

METAL INDUSTRIES, Ltd., Brook House, Park Lane, London, W.1, states that contracts have been exchanged under which it is to acquire John Lee, a firm of scrap iron, steel and metal merchants, of 80, Corporation Street, Belfast, 1, and Milewater Basin, Belfast Harbour. The business is being transferred immediately to Cox and Danks, Ltd., a wholly-owned subsidiary of Metal Industries, Ltd., but will be conducted until further notice under the name of John Lee.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., announces that it has formed a steel processes division to absorb the personnel and carry on the work previously undertaken by Davy British Oxygen, Ltd. Davy British Oxygen was established over three years' ago jointly by Davy-United and British Oxygen to investigate the various kinds of pneumatic steel-making processes and to carry out the basic engineering studies necessary for the design of complete oxygen steel-making plants. The two companies have agreed that the execution of prospective contracts for oxygen steel melting shops should be handled by Davy-United, although Davy British Oxygen will remain in existence and act as the focal point for future collaboration in this field. Davy-United's steel processes division is at Suffolk House, Suffolk Road, Sheffield, 2.

POWELL DUFFRYN, Ltd., announces that a conditional offer which has been made for the purchase of the share capital of Hurseal, Ltd., consisting of 160,000 ordinary shares of £1 each, at a price of 47s. 6d. per share, has been accepted in respect of the whole of the share capital. The purchase of these shares by Powell Duffryn is accordingly taking place under the terms of the offer. The board of Hurseal, Ltd., has been reconstructed. Mr. Miles Reid, a director of Powell Duffryn, Ltd., has joined the board as chairman in succession to Mr. R. S. Bassett, who retires. Mr. O. Keir and Mr. B. W. Wade also retire. Mr. W. H. Sharland, deputy chairman of Powell Duffryn, Ltd., and Mr. R. Turner, managing director of Powell Duffryn Technical Services, Ltd., join the board. Mr. A. C. Hazel will continue as managing director and Mr. H. Hollesen, of Hollesens Fabrikker of Copenhagen, and Mr. B. L. B. Hutchings also continue as directors of the company under its new ownership.

Contracts

BRISTOL COMMERCIAL VEHICLES, Ltd., of Brislington, Bristol, has placed an order with Heenan and Froude, Ltd., of Worcester, for a Heenan Electric dynamometer for use in the company's experimental department for single-cylinder development of compression-ignition engines for their vehicles.

CHARLES CONNELL AND CO., Ltd., has received from Ben Line Steamers, Ltd., an order for a cargo-passenger liner of 13,250 tons deadweight and a capacity of 675,000 cubic feet. The ship will be powered by a ten-cylinder Rowan-Sulzer oil engine developing 13,500 b.h.p., and giving a service speed of over 19 knots.

COWANS, SHELDON AND CO., Ltd., of Carlisle, has received the order for two diesel railroad wrecking cranes from the Quebec Cartier Mining Company in Montreal, Canada. These wrecking cranes are of 250 tons and 150 tons lifting capacity and are stated to be the largest of their type yet built. The value of the order for these cranes and their associated equipment is about £175,000.

SIMONS-LOBNITZ, Ltd., has received an order from British Transport Docks for a diesel-electric suction dredger. This is a twin side-pipe trailing hopper craft of 180ft length between perpendiculars, 38ft 6in breadth moulded, 17ft 3in depth moulded, hopper capacity 850 cubic yards, dredging depth 40ft, and speed 10½ knots. Power units will be two Mirrlees J.LSm8 diesel engines driving Brush generators.

CONTINENTAL AFFAIRS

by Our Continental Editor

Dutch Transonic Wind Tunnel

One of the most powerful wind tunnel installations in Europe was inaugurated recently. The High Speed Tunnel (H.S.T.) at Amsterdam has a test section of 2m by 1·6m, and covers the subsonic and transonic range, up to Mach 1·3. The tunnel, powered by a 20,000 h.p. compressor, is an integral structure. Its comparatively modest weight is largely due to the fact that a compressed air test was applied in place of the usual water pressure test.

IN the development of aeronautics in the Netherlands a key role is being played by the Nationaal Luchvaartlaboratorium (National Aeronautical Research Institute, N.L.L.), the successor, in 1937, of the Rijksstudiedienst voor de Luchtvaart (Government Aeronautical Institute) established in 1919. The N.L.L. has its principal laboratories and wind tunnel installations at Amsterdam. It comprises divisions concerned with aerodynamics, flight testing, free-flight model testing, flutter, combustion, helicopters, structures, and materials, which are backed up by a data processing service, library, workshops, design office, and other departments; altogether the staff numbers about 350 persons, including seventy university graduates and fifty graduates of technical colleges.

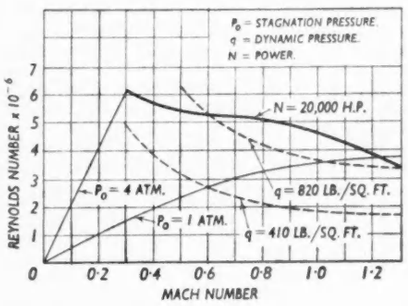


Fig. 1—Reynolds-Mach diagram for the H.S.T. for a characteristic length l=0·24m, and a stagnation temperature of 303 deg. K.

On the governing board are represented the civil and military government departments, the aircraft industry, and the airlines, while a committee of independent experts advises on technical and scientific matters. The N.L.L. obtains its funds partly from government grants and partly from research contracts. Installations include five wind tunnels, with two further tunnels under construction, two laboratory aeroplanes, flight test equipment for aircraft and flying models, test benches for ramjets, equipment for testing materials and structures, analogue and digital computers, &c. As the present site does not permit any further expansion, an additional area has been acquired in the Noord-Oost Polder—the north-eastern part of the reclaimed Zuiderzee—where several facilities are under construction, including a tunnel for Mach 1·4–4 with a 1·4m by 1·4m test section, and another for up to Mach 6 with a section of 0·27m by 0·27m.

The most recent addition to the facilities at N.L.L. is the High Speed Tunnel (H.S.T.) for a Mach range of 0 to 1·3, with a working section 2m wide by 1·6m high. It is a closed-circuit tunnel capable of operating at stagnation pressures from 0·125 to 4 atmospheres absolute, and driven by a 20,000 h.p. compressor. Its Reynolds-Mach diagram is shown in Fig. 1.

Wall interference in the transonic region (Mach 0·7 to 1·3) is suppressed by means of slots in the wall surface of the test section. The tunnel is amply equipped with measuring facilities, including a remote controlled schlieren and shadowgraph system with closed-circuit television. Within a certain pressure range, the test chamber is accessible through an air lock. Much attention is being devoted to fast processing of data.

The H.S.T. is of integral welded construction, which alleviates foundation problems but introduces certain difficulties due to expansion. By forgoing the water pressure test which, owing to the great mass of water required, would otherwise have been the dominating factor in stressing the tunnel, a much more economical design could be achieved. In place of the water test, a compressed air test (to 3·3 atmospheres gauge) was carried out, with the main object, not of proving the strength of the structure, but to make sure there was no possibility of fatigue failure through stresses reaching the yield value at any point. Stress measurements were carried out at about 150 positions and carefully compared with calculated values, before applying the full test.

Layout

Our accompanying illustration (Fig. 2) shows a general view of the tunnel, while Fig. 3 indicates the arrangement. The circuit is rectangular and measures 58·98m by 11·26m over centres. At the cooler where it is largest, the pressure shell has a diameter of 12m; its total volume is 4700 cubic metres, and its weight, about 600 tonnes (to which must be added another 300 tonnes for internal equipment).

The hot leg extends over approximately 74m from the compressor to the cooler, and comprises a parallel section followed by a 5 deg. diffuser and two right-angle bends fitted with turning vanes (Fig. 3).

After the cooler come five anti-turbulence screens, then the convergent section with variable throat, and the test chamber. The air returns to the compressor through the cold diffuser and two right-angle bends with turning vanes.

The H.S.T. is one of the largest wind tunnels in Europe. Its main data are shown in Table I.

TABLE I—*Principal Data of H.S.T.*

Design	Closed circuit pressurised tunnel
Circuit (centres)	58·98m by 11·26m
Volume	4700 cubic metres
Steel weight of shell	600 tonnes
Total weight with fittings	900 tonnes
Mach range	0 to 1·3
Maximum Reynolds number (at Mach 0·3)	6×10^6
Reynolds number at maximum Mach (for characteristic length 0·24m, stagnation temperature = 303 deg. K.)	3×10^6
Stagnation pressure	0·125 to 4 ata.
Compressor :	
Horsepower	20,000
Maximum speed	620 r.p.m.
Number of stages	Four
Airflow	850 cubic metres per second
Control	Speed and blade pitch
Cooler :	
Water flow rate	1800 cubic metres per hour
Temperature rise of water	7 deg. Cent.
Temperature drop of air	20 deg. Cent.
Downstream air temperature variation	±1·5 deg. Cent.
Test chamber :	
Design	12·5 per cent slotted wall and plenum with access through airlock
Section	2m wide by 1·6m high by 2·6m long
Main motors	4 × 5000 h.p., 2·7kV
Power house :	
Number and output of boilers	5 × 27 tons per hour
Steam conditions	360 deg. Cent., 33 atm.
Number and output of turbo-sets	4 × 4600kW
Speed	1100–5600 r.p.m.
Maximum frequency	93½ c/s
Air compressor, delivery pressure	40 atm.
Air pressure vessel, volume	600 cubic metres

Fig. 2—High-speed wind tunnel seen from the north-west. The duct for the compressor drive is on the right. On the left, the cooler and test section with access airlock. Reinforcing ribs are clearly seen (note double rings at corners), as are some of the supports

CONTINENTAL AFFAIRS *(Continued)*

Compressor

The tunnel airflow of up to 850 cubic metres per second derives from a 20,000 h.p. compressor driven through a floating shaft (permitting variations in level of ±1·5cm) and flexible couplings by four 5000 h.p. motors. The compressor is a four-stage machine, designed for a maximum speed of 620 r.p.m. There are forty-seven blades in each stator, and twenty-two blades in each rotor stage.

The stator casing for machining purposes was made in two sections, as well as being split horizontally. It has an internal diameter of 4·8m and is flanged at each end to the adjoining tunnel shell.

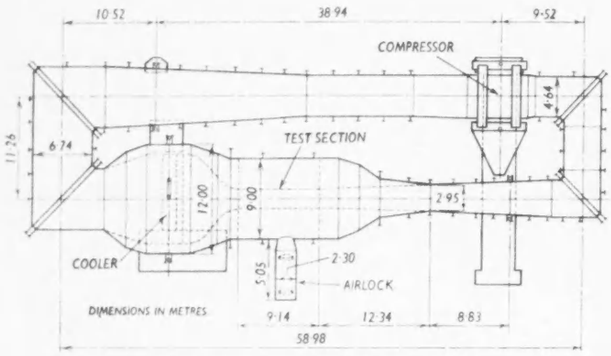


Fig. 3—General arrangement of layout of wind tunnel

The rotor, which weighs about 30 tonnes, is supported in two bearings spaced 5·13m apart, the end thrust being taken up by a Michell bearing. The hub takes the form of a drum 1·8m in diameter and 4·08m long carrying four rings of 3·2m outside diameter in which are housed the stub shafts of the variable pitch blades. By longitudinally moving a central drum, with which the arms on the stub shafts are in engagement, the blade pitch can be varied between 0 and 60 deg. with an accuracy of 0·02 deg. Oil pressure is used to actuate the drum, the movement being fed back mechanically to the control valve so as to shut it off when the desired position has been reached. Both the desired and the actual position of the blades are shown on the same scale by large pointers whose coincidence indicates completion of the adjustment. The servo mechanism can be operated electrically from the tunnel control desk at four speeds, from a few hundredths of a degree per minute to ½ deg. per minute; at the maximum speed the blades can also be controlled locally for maintenance.

While a coarse adjustment of the airflow can be made by varying the compressor speed, this is too sluggish to give the required degree of adjustment, or permit a quick shut-down. By altering the blade setting a fine adjustment of the flow can readily be made, and if required the tunnel may be stopped by returning the rotor to zero pitch.

Since oil spray or vapour must not enter the tunnel, care was taken to keep the pressure inside and outside the bearing housings equalised. In addition, the bearings are fitted with labyrinth glands from which contaminated air is constantly withdrawn. After being cleaned in active carbon filters, the air is returned to the glands.

Balancing of the rotor presented a problem, as the size of the machine prevented this being done in the maker's works. Accordingly, it was decided to carry out balancing *in situ*. Initially, at non-resonant frequencies, the amplitude at the bearings was about 5μ, and that of the tunnel, 200μ; while in conditions of resonance, vibration became excessive, reaching amplitudes of up to 100μ at the bearings, and 2000μ in the tunnel. Up to and including the full compressor speed the tunnel has nine natural frequencies, and while one endeavours to operate as far away from these as possible, in addition a high degree of balance is particularly important. Initial balancing was done by adding known masses at the ends of the rotor and measuring the amplitude and phase angle of the vibration. For the final balancing this method did not prove sensitive enough because of disturbing factors, such as bearing play and vibrations, transmitted from outside the system. Accordingly, use was made of the fact that at resonance the tunnel constitutes a very selective amplifier, with a gain of about 50. The final tests were run at a pair of resonant frequencies (the seventh and eighth, and the eighth and ninth harmonic), taking measurements at a single point at the centre of the opposite limb of the tunnel where the amplitude was a maximum and which was farthest from the point of excitation where most of the disturbances were introduced. In the end, the rotor was balanced to such a degree that at none of the resonant frequencies did the bearing amplitude exceed 4μ or the tunnel amplitude at any point 34μ.

Strain gauge measurements were also carried out to determine the effect of vibrations on the rotor blades. Torsional stresses were found to be small under all conditions, and bending stresses did not exceed 4 kg per square millimetre, even during surging, which those measurements helped to pinpoint very closely.

Cooler, Contraction, and Test Section

In the hot diffuser section, the tunnel expands from 4·8m to 6·74m, and after two right-angle bends widens to 10m in a cone having an angle of 40 deg., before reaching the cooler. In spite of this last enlargement being so rapid, losses are kept small because of the comparatively low kinetic energy in this zone of slow velocity, and because the air resistance of the cooler which, moreover, is artificially increased by a wire screen in the expansion cone, helps to push the flow against the walls.

As Fig. 4 shows, from the beginning of the expansion cone to the end of the first portion of the cold diffuser, the pressure shell forms an outer casing for the tunnel liner and the test section. Over this length, the shell increases from a diameter of 6·74m to 12m, and decreases again to 9m at the test section, and finally to 2·95m. A number of bulkheads serve as supports for the internal components, and to isolate the consecutive sections from each other. Because of the extreme variation in the air velocity, the static pressures can differ by as much as 1·2 atmospheres. By isolating the sections, the tunnel liner is subjected only to small pressure differences so that a lighter thickness of metal could be used, which made it easier to construct the more complicated duct profile which occurs here. Moreover, around the test section a plenum is created which is at the same pressure as the interior of the test section.

The cooler is octagonal in shape, measuring 10m across opposite sides, and comprises ten sections of different lengths. Each section consists of two vertical banks of finned elliptical tubes, one bank arranged behind the other, the water passing through in counterflow. The cooling water connections are made with flexible bellows so as to allow for expansion. The cooler can absorb the thermal equivalent of 20,000 h.p., and give a downstream air temperature uniform to within ±1·5 deg. Cent. This small variation in the air temperature requires a high rate of flow, amounting to about 1800 cubic metres per hour. By varying the coolant flow, the stagnation temperature of the tunnel can be adjusted. Under normal conditions the cooling water increases in temperature by 7 deg. Cent., and the air is cooled through 20 deg. Cent. The difference in temperature between the air leaving the cooler and the cooling water at the inlet is 30 deg. to 40 deg. Cent.

Downstream of the cooler are placed five anti-turbulence screens made of 0·2mm diameter wire with mesh centres at 0·9mm. The air velocity here is about 10m per second. The screens are followed by the contraction having an area ratio of 25 : 1.

The tunnel liner then passes through the first of the two bulkheads which close off the plenum around the test section from the rest of the tunnel. These bulkheads are stiffened by radial ribs flexibly attached to the shell and support an 8·5m long, 3·8m high, and 2·7m wide, assembly

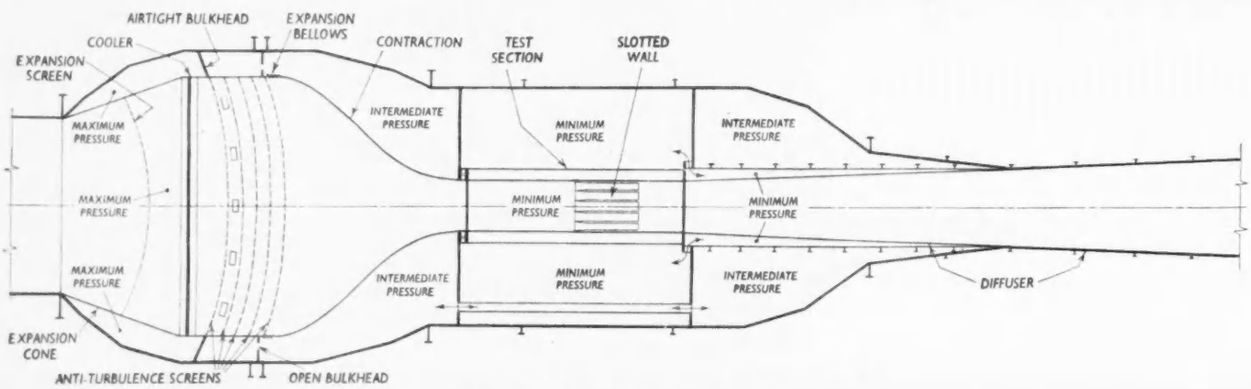


Fig. 4—Horizontal section through cooler, test chamber and diffusers

incorporating a variable De Laval nozzle and the test section. On account of the great stiffness required, the supporting structure alone weighs 45 tonnes, so that the whole assembly attains a weight of 70 tonnes. It consists principally of two rectangular end flanges connected at top and bottom by cross-braced box girders measuring in section 0·9m by 0·4m.

In the leading part of the assembly is the adjustable De Laval nozzle, having an upper and lower rigidly-contoured throat profile which can be moved in an out at the leading end while turning about a longitudinally sliding fulcrum near the trailing end. The gap between the trailing end and the chamber wall is bridged by a flexible steel plate which can be additionally deflected by an auxiliary hydraulic jack set in the centre. The higher the Mach number, the more the throat has to be narrowed. The side walls of the nozzle are fixed and not adjustable.

The test section which then follows is equipped with a 12·5 per cent slotted top and bottom to suppress shock waves, the air diffusing out through the slots being ejected again from the plenum by the diffuser. In addition to the possibility of adopting a slotted wall test section, the use of a plenum removes the need to have pressure-resisting observation windows.

Each side wall has three large windows through which schlieren observations can be made. The optical equipment for this can be

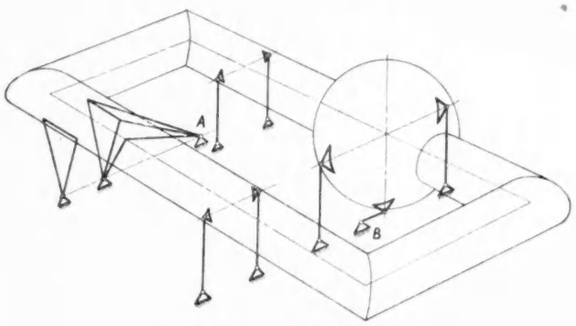


Fig. 5—Diagrammatic view of supports

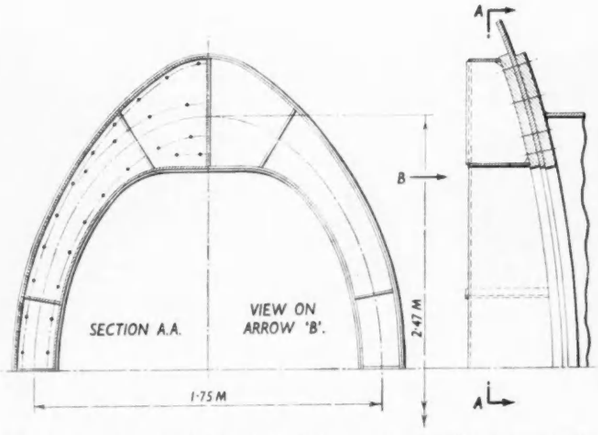


Fig. 6—"Neutral hole" intersection between pressure shell and access tube

moved in all directions as well as rotated about a vertical and a horizontal axis. For this purpose it is mounted in a yoke suspended at each end by independently controlled wires, the yoke itself being rotatably mounted on the crab of an overhead travelling crane.

The illumination is either continuous or flashlight, the schlieren or shadow images being observed by a television camera or recorded photographically. All moments and settings are controlled from outside the tunnel.

In transonic tests the model is supported on a tail sting attached to a faired support. The latter can be raised or lowered by mechanical and hydraulic means, and the sting can be tilted so as to vary the angle of attack. A remote yaw control is being designed.

For tests at subsonic speeds the model is supported at the fuselage. In half-model tests, one of the observation windows is replaced by a steel plate on which the model is mounted, while in two-dimensional tests the model is carried between two such steel plates. Preparations for dynamic stability testing are being made.

The measurement of forces and moments is done with calibrated strain gauges, the set-up being corrected for deflection. Equipment for pressure measurements includes a forty-position static tube for determining longitudinal pressure distributions inside the test section. For transverse measurements a rake-like holder makes it possible to set up nine sets of static tubes, Pitot tubes, or hot wire anemometers, for determinations of static and total pressure, velocities and turbulence. For finding pressure distributions over the surface of a model, there is available a mercury multi-manometer with 162 tubes.

Cold Diffuser

The test section is followed by the cold diffuser which comprises two parts. The first is a 12·34m long liner within the outer tunnel shell, and forms the transition from rectangular to circular section. At 2·95m diameter begins the second part of the diffuser which is formed by the shell itself, and continues through two right-angle bends to the compressor inlet. The opening angle of the diffuser as far as the first bend is 5 deg.; from there onwards it is about 3 deg.

Turning Vanes

All four bends are fitted with turning vanes, which are fixed at the bottom, and free at the top to expand vertically. The vanes are of sheet material, with a section in the form of a 96 deg. circular arc extending into flat tangential leading and trailing portions. The chord length varies between 972mm and about 1595mm, the pitch being 0·4 times the chord. A number of horizontal ribs in each vane stiffen the profile.

Power House

Energy for the compressor motors is derived from four 4600kW turbo-generator sets, generating at 2·7kV with a maximum frequency of 93⅓ c/s, their speed being variable between 1100 and 5600 r.p.m. Steam at 360 deg. Cent., 33 atmospheres, is supplied from five 27 tonnes per hour boilers. A fifth turbine is installed for powering an air compressor, with a delivery pressure of 40 atmospheres. This air is stored in a 600 cubic metres pressure vessel, for boosting the H.S.T., and for driving intermittent tunnels. Water for the jet pump used to evacuate the high-speed tunnel is supplied by the cooling water pumps of the power house. It takes up to fifteen minutes to bring the tunnel to its maximum pressure of 4 atmospheres, and half to three-quarters of an hour to evacuate it to 0·7 atmosphere. Higher vacua require much longer pumping, e.g. ¼ atmosphere takes about two-and-a-half hours to reach.

The electric power generated is used to drive the four 5000 h.p. main motors which are arranged in line, and are normally connected in parallel. Alternatively, the power station can be used to drive another, smaller, tunnel.

Design

In an integral tunnel like the present, the shell takes up all forces arising from the operation of the tunnel, a fact which greatly simplifies the design of the supporting structures. At the Amsterdam site this represents a great economy, as it avoids the need for extensive piled foundations which, with a sectional tunnel, would be required for transmitting the large unbalanced forces and moments. These also require extra steel for strengthening the shell at the points of attachment of the supports.

On the other hand, the integral construction makes it more difficult to handle temperature stresses which arise from three main causes, a temperature difference of about 20 deg. Cent. between the hot and cold halves of the circuit, solar radiation tending to produce upward arching between supports, and snow, which by chilling the top, producing downward arching. The temperature differences across the tunnel section which were assumed for design purposes where 20–25 deg. Cent. from solar radiation, and up to 70 deg. Cent. from the action of a snow cover. To reduce the effect of solar radiation the tunnel is painted with aluminium paint and part of the shell at the test chamber is protected by a roof.

The tunnel is constructed of structural mild steel plate, mostly 15mm, but thickening to 25mm near the corners and 32mm at the corners themselves, where an elliptical ring forms the transition between the two circular sections at right angles. The shell is stiffened by external flanged frames. At the corners and supports, pairs of particularly heavy frames are employed.

As shown in Fig. 5, the supports are arranged in four places. At three of these are pairs of vertical steel columns arranged to permit horizontal deflection. The compressor at *A* is supported in a more elaborate manner by two columns, of which the inner one prevents overturning about the compressor axis and horizontal movement at right angles to it, but allowing limited axial movement by means of flexible pivot joints. The outer support also allows some axial movement. The arrangement

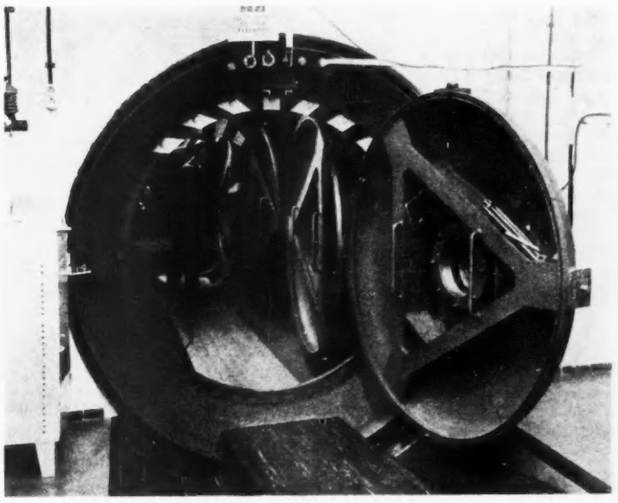
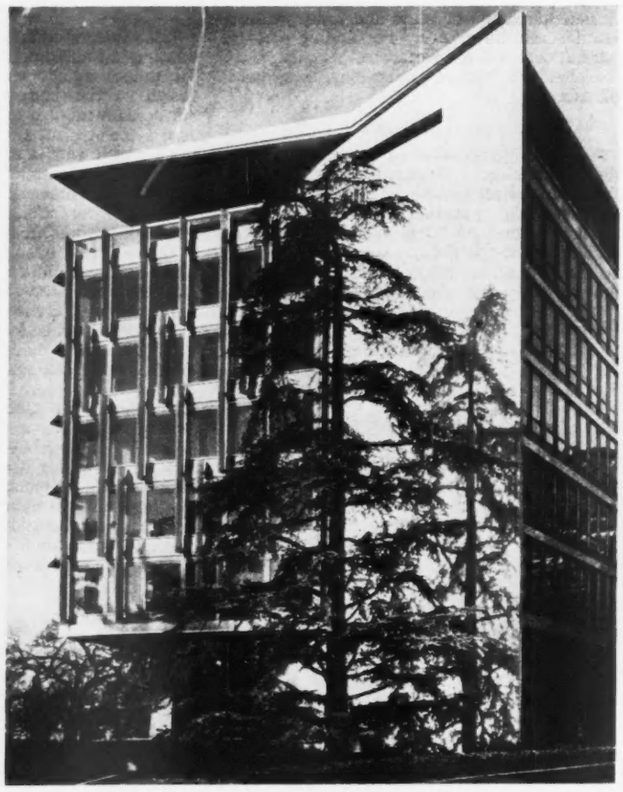


Fig. 7—Airlock showing the two sets of doors

CONTINENTAL AFFAIRS *(Continued)*

can absorb out-of-balance forces of up to 400 tonnes, such as may arise from blade failure. Transverse displacement is also restricted at *B* by a horizontal anchor. Provision is made against lifting of the supports. In order to suppress vibrations, a pair of columns incorporating oil dampers is attached at the compressor bend. These columns offer no resistance to static loads. They are mutually at right angles, and thus serve to damp out both the horizontal and vertical components of the vibration. At all the supports, levels can be checked and adjusted in case of subsidence.

An interesting solution was adopted for the intersection between the main shell and the access tube. This is based on the "neutral hole" method (E. H. Mansfield, 1955) in which the edge of a cut-out is reinforced so as to leave the stress system in the plate undisturbed. For a principal stress ratio of 2 : 1, as in pressure vessels, the solution to the plane problem is an elliptical hole with edge reinforcement varying in area, the ratio at the ends of the long and short axes of the ellipse being 2·8 : 1. In the present case, 50mm thick reinforcement plates were riveted inside and out to the 25mm thick shell (Fig. 6). The membrane forces no longer balance because of the fact that the shell is no longer plane but circular, but equilibrium is restored by the access tube which is attached along the line of the ellipse. The transition of this tube from elliptical to circular at the airlock doors (Fig. 7) is externally reinforced by rings.



Head office building of Nestlé at Vevey

MAIN CONTRACTORS

Pressure shell and auxiliaries: Werkspoor N.V., Amsterdam. Compressor: Dinglerwerke A.G., Zweibrücken. Test section and part of measuring equipment: Dätwyler and Hausammann, Zurich. Cooler: G.E.A. Luftkühler-Gesellschaft, Bochum. Steam plant: N.V. Stork, Hengelo. Electric machinery: Heemaf, Hengelo. Consultants: N.V. tot Keuring van Elektrotechnische Materialen (K.E.M.A.), Arnhem; Koninklijke Marine. Architect: Maaskant, Rotterdam. Structural work: N.V. Bataafsche Aanneming Maatschappij, Amsterdam.

Geneva Motor Show

On March 25, page 540, under the title "Geneva Motor Show No. I," we referred to the Gordon Gran Turismo car, and in particular to the operation of the front and rear brakes by separate hydraulic circuits. We now learn that, although these hydraulic systems are not servo-assisted, the brakes are in fact disc brakes of Girling manufacture. The system is designed to give a retardation of 28ft per second per second for a pedal force of 117 lb, a 60/40 distribution of effort resulting with a pressure of 980 lb per square inch in the front system and 1180 lb per square inch in the rear. The discs themselves are respectively 11⅛in diameter by ½in and 11⅜in diameter by ⅜in.

Award to Professor Tschumi

The American Institute of Architects has announced that Jean Tschumi, professor of architecture at the Polytechnic School of the University of Lausanne since 1943, and president of the International Union of Architects 1954–58, is to receive the 1960 Reynolds Memorial Award. Professor Tschumi was chosen unanimously by the A.I.A. Jury (chairman, Dr. Walter Gropius) for his design of the seven-storey Nestlé's International Headquarters building. It is located in a park in Vevey, on the shore of Lake Geneva.

The 25,000 dollars R. S. Reynolds Memorial Award is conferred annually on the designer of the foremost contemporary structure in the world, using aluminium in a manner which could significantly influence present-day architecture.

The building, which we show in the accompanying illustration, is built in a Y-shape so as to give all the offices views towards Lake Geneva or the mountains. The curved façade, resulting from this floor plan, lends variety to the outside. Basement and ground floor are of reinforced concrete, while the upper floors have a welded steel frame with an aluminium curtain wall. The entire ground floor has glass walls so that motorists driving on the main road can look through and see the lake and the mountains beyond. The silhouette is made more striking by the deeply undercut penthouse under the roof. Of particular interest are the vertical baffles and sunshades which protect the rooms without hiding the view from inside, and help to lend variety to the long rows of windows. Among individual details may be mentioned the large entrance canopy, 44ft long and having a free cantilever span of 33ft 6in. It is constructed of aluminium sheet only 3mm thick with 5mm thick extensions for the cantilevers.

New Elementary Particle

The discovery is reported from the Joint Nuclear Research Institute, Dubna, near Moscow, of a positively charged anti-sigma-hyperon. The work was carried out by an international team including Professor Wang Kang-Chang, of China, Acadamician V. Veksler, and other scientists. The particle has a mass of about 2300 times that of an electron, and a life of about 10^{-10} seconds, after which it disintegrates into an anti-neutron and a positively-charged π-meson, i.e. a meson of 273 times the electron mass. Experimental work involved the study of some 40,000 photographs of tracks observed in a propane bubble chamber.

Mallet Giving Low-Peak-Force Impulses

An unusual tool has been introduced by Hazet-Werk (Hermann Zerver, Remscheid-Vieringhausen) for use in such tasks as fitting window glasses, knocking on car hub covers, and beating out dented panels. It resembles a rubber mallet, as can be seen in our illustration, but

This rubber-covered mallet has a plastic filling that renders it completely "dead"

in fact the weighted head is filled with a plastic of high hysteresis; consequently the mallet is virtually "dead" and has no tendency to bounce off the object struck. With this tool inadvertent damage to paint work can hardly occur; even the handle is rubber-covered. The weight quoted is 1300 grammes (2 lb 14 oz).

U.S.-Euratom Joint Programme

The U.S.-Euratom Joint Research and Development Office announced recently that by May 15 more than 200 proposals and letters of intent to participate in the U.S.-Euratom research and development programme had been received from firms, research groups and educational institutions, both in the Community and the United States. The total sum involved in the definite proposals amounts to about 37,000,000 dollars.

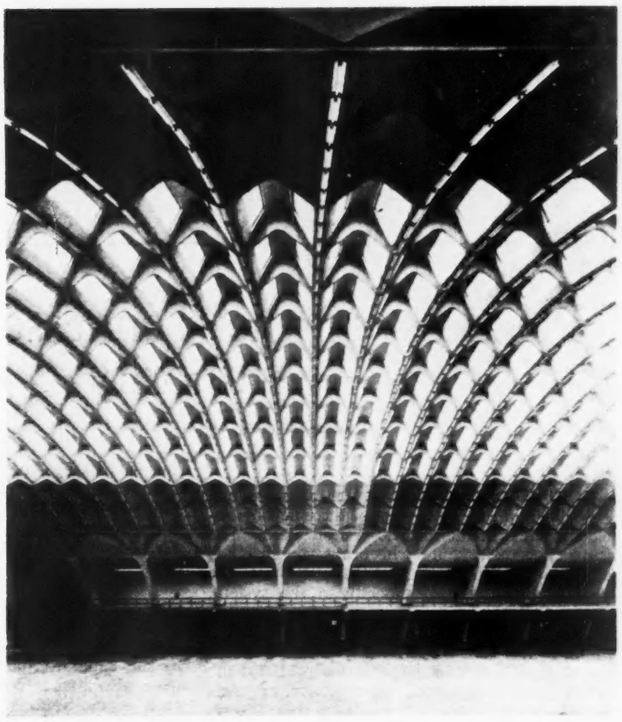
One of the essential elements of the U.S.-Euratom agreement lies in the ten-year research and development programme, which aims at lowering the cost of energy provided by the nuclear reactors which will be built in the countries of the Community during the coming few years within the framework of the vast joint programme for the development of nuclear energy. The invitation to take part in the research and development programme was put out jointly by the Euratom Commission and the U.S. Atomic Energy Commission on December 23, 1958. Under the terms of the U.S.-Euratom agreement this programme will extend over a period of ten years, each of the contracting parties contributing approximately 50,000,000 dollars in the course of the first five years.

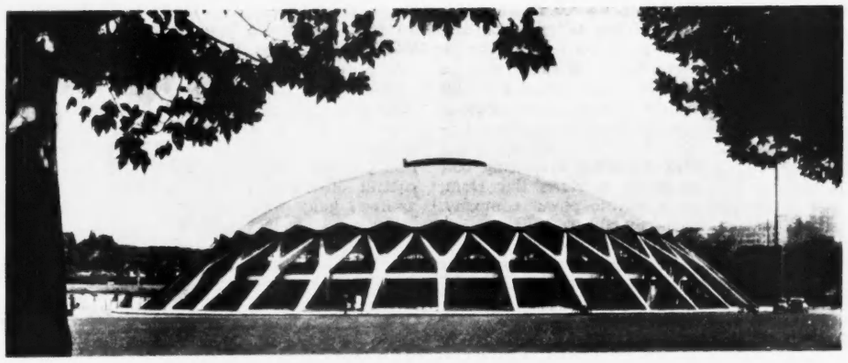
The response to the invitation shows that both in the Community and the United States there is a very wide interest in the common programme agreed between the two sides.

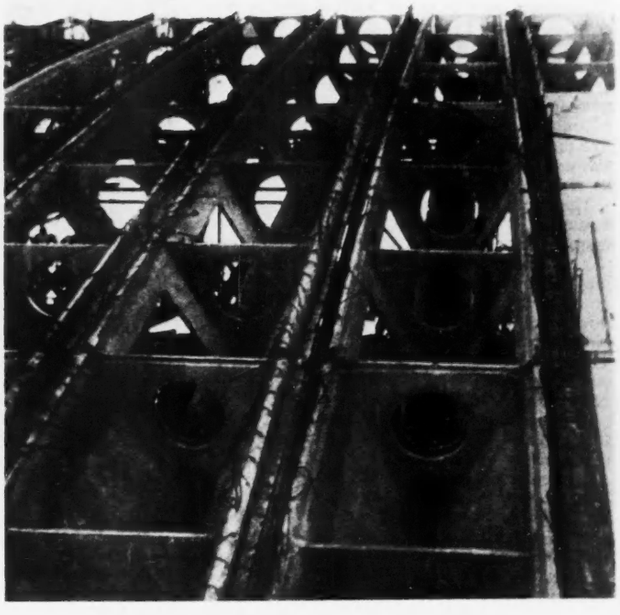
The Work of P. L. Nervi

Professor Pier Luigi Nervi, who, on April 5, received the Royal Gold Medal for Architecture, was born at Sondrio in 1891 and graduated at Bologna in 1913. In 1923, he founded his own firm of contractors and thus achieved what he considers an essential unification of all aspects and stages of structural design. One of his earliest works in private practice was the sports stadium at Florence (1927–1932), which includes a grandstand canopy with a cantilever span of 70ft. There followed, from 1935 onwards, the military aircraft hangars at Orvieto and Orbetello, with clear spans of 330ft by 130ft. The intersecting ribs of the vaulted roofs involved elaborate formwork and, in order to save the need for this, Nervi turned to prefabrication. From 1943 onwards, he experimented with "ferro-cemento," consisting of wire-mesh and small bars embedded in thin sections of high-grade cement-sand mortar. At first considered for building ships—Nervi still uses a ferro-cemento yacht—the new material proved eminently suitable for prefabricated panels, forming at the same time the permanent shuttering for *in situ* reinforced ribs and any top cover which might be applied, and requiring no subsequent internal finishing operation.

The main exhibition hall at Turin (RIGHT) represents an early application of these ideas ; it was completed from beginning to end in only six months. On Plate 16 in our issue of January 1, we referred to the "Palazzo dello Sport," one of the structures designed by Nervi (in collaboration with the architects A. Vitellozzi, M. Piacentini, and Antonio Nervi) for this year's Olympic games in Rome. BOTTOM, RIGHT, are seen some of the prefabricated elements of the 330ft diameter cupola, before placing the *in situ* concrete in the valleys and ridges and the precast top slabs. The hollow radial vee-sections, 4ft deep at the edge of the roof and 1ft at the centre opening, accommodate indirect lighting, sound-absorbing material and ventilating ducts. The "Palazzetto dello Sport" (CENTRE), which is 200ft in diameter, uses 1620 roof elements of only nineteen different shapes, some of which are shown (BOTTOM, LEFT) during positioning of the reinforcements for the ribs and outer roof skin. The elements are 2·5cm thick and weigh up to 350 kg; the outer concrete has a thickness of 3cm. On top were placed 5cm of insulation, which was covered with bitumen-impregnated jute. Assembly and completion of the cupola required forty working days. Like the larger dome, the "Palazzetto" is supported on inclined columns ; the "Palazzo" columns (illustrated loc. cit.) are of twisted section, the surface being generated by means of straight, narrow shuttering boards ; a device used by Nervi elsewhere, e.g. in the "Corso Francia" elevated road to the Olympic village, which is now being completed. Among more orthodox structures may be mentioned the Pirelli skyscraper in Milan (in collaboration with Ponti) and (in collaboration with the architects Breuer and Zehrfuss) the U.N.E.S.C.O. headquarters in Paris.







THE AMERICAN SCENE

by Our American Editor

Progress of the Tennessee Valley Authority

No. II—(*Continued from page 628, April 8*)

Hydro-Electric Construction

ACTIVE construction was started in March, 1959, on the installation of three new hydro-electric units at the historic Wilson Dam. The three 54,000kW units will bring the installed capacity at Wilson, which already has the greatest hydro-electric capacity in the system, to 598,000kW. Wilson Dam was started during World War I and was placed in operation initially in 1925. When the plant was transferred from the War Department in 1933, the power station contained eight generating units with a total installed capacity of 184,000kW. There were ten vacant stalls in the power station for additional units. As upstream storage was provided by the construction of new dams, the additional units were installed during the ten years 1940–50 to take advantage of the improved water supply. They brought the installation to its present 436,000kW capacity.

The present construction involves the installation of three "outdoor" units at the end of the existing power station. Economies are being achieved by using the construction plant facilities, shops, and offices which were used in connection with the construction of the new Wilson lock. A special floating bulkhead, used to seal off the upstream side of the dam for the construction of the lock, also was being modified at the end of the year for use in installing the penstocks for the new hydro-electric units.

Plans were also made during the year to add three generating units at the Wheeler Dam, 15½ miles upstream from Wilson. The new units will be of 32,400kW capacity each, the same as the eight units now installed. The total installed capacity at Wheeler will be raised from 259,200kW to 356,400kW.

Wilson Dam Lock

Construction of the new 100ft single-lift lock at Wilson neared completion, but the scheduled operating date had to be postponed from June to November because of delay in the delivery of the lower lock gate. The delay resulted from a sixty-day strike combined with fabrication difficulties at the works of the manufacturer. The erection of the south leaf of the lower gate was delayed until the faulty pintle bearing could be replaced.

The new lock eliminates the most serious bottleneck to the growing traffic on the Tennessee waterway. The 100ft single lift lock—the highest in the world—has a chamber 600ft long and 110ft wide. It will be capable of accommodating nine of the "jumbo" barges now widely used on the river. Chambers at the old tandem locks can handle only one at a time. The "jumbo" barges, 35ft wide and 194ft long, commonly carry 1500 tons of cargo. Thus the new lock will be able to handle 13,500 tons of cargo in a single lockage. The average lockage time for tows will be reduced from five hours to one hour or less.

While the completion of the lock proper was delayed, other aspects of the project continued on schedule. The new high-level bridge spanning both the old and the new locks was completed and opened to traffic in March. It replaces the old roadway in the lock section of the dam where the opening of the drawbridge during locking operations often caused long traffic delays. The deepened 2¾ mile long Florence Canal leading to the lock was placed in operation over most of its length in May. Traffic continued to use the lower part of the canal through Lock and Dam No. 1, which later will be by-passed when modifications of the old tandem lock are completed.

A dyke and seven sheet piling cells were constructed between the river and the entrance to the canal to reduce cross currents. Plans were also made to replace the present swing span of the Southern Railway bridge over the Tennessee just below the mouth of the canal with a vertical lift span. By eliminating the central pier on which the swing span turns, clear entrance to the canal is assured. Construction on the bridge changes was started late in 1959. With the completion of the Wilson lock and canal project, the three dams farthest downstream on the Tennessee waterway will be equipped with 110ft by 600ft locks, this size having been built in the original construction of Pickwick Landing and Kentucky dams. Upstream, all but one of the dams have smaller standard locks, with chambers measuring 60ft by 360ft. The exception is Hales Bar Dam, formerly owned by a private power company, where the chamber is only 60ft by 265ft.

The new Wilson dam lock (Figs. 6-9) now completed is at a point where, in earlier times, shoals and rapids severely hampered and occasionally prevented navigation in a reach of the Tennessee River that drops nearly 100ft in 27 miles. Begun in July, 1956, the lock structure was formally opened in November, 1959. The entire project, including deepening of one of the present lock chambers and related canal changes, cost 38,000,000 dollars.

Situated on the north river bank, the present navigation facilities consist of a double-lift lock at the dam, a canal 2¼ miles long below the dam, separated from the main river channel by Patton Island, and a single-lift lock and dam at the lower end of the canal. The double-lift lock has two chambers in tandem with a combined lift of 90ft; these chambers are separated from the spillway by a 200ft non-overflow dam section. The dimensions of the upper and lower chambers are 60ft by 292ft and 60ft by 300ft respectively. The lock at the lower end of the canal has a maximum lift of 10ft; its lock chamber is 60ft by 298ft. To accommodate the new 110ft by 600ft lock chamber in the existing dam structure, eight spillway gates adjacent to the present tandem lock facilities were removed. The resulting reduction of spillway capacity, from the original fifty-eight gates to fifty, was made possible by the combined effect of upstream river regulation, virtually non-existent when the dam was built, and the installation of additional power units at the dam. The new lock chamber is entirely downstream from the dam to avoid a very costly upstream cofferdam in over 80ft of water. The upper sill and gate rest on the old dam. The lock walls extend downstream 800ft supplemented by a spillway guide wall 635ft long. To handle the 100ft total lift, a double-leaf mitre gate 117ft high was installed at the downstream end. The 20,000 cusecs of water needed to fill the lock chamber enter through a 15ft by 15ft

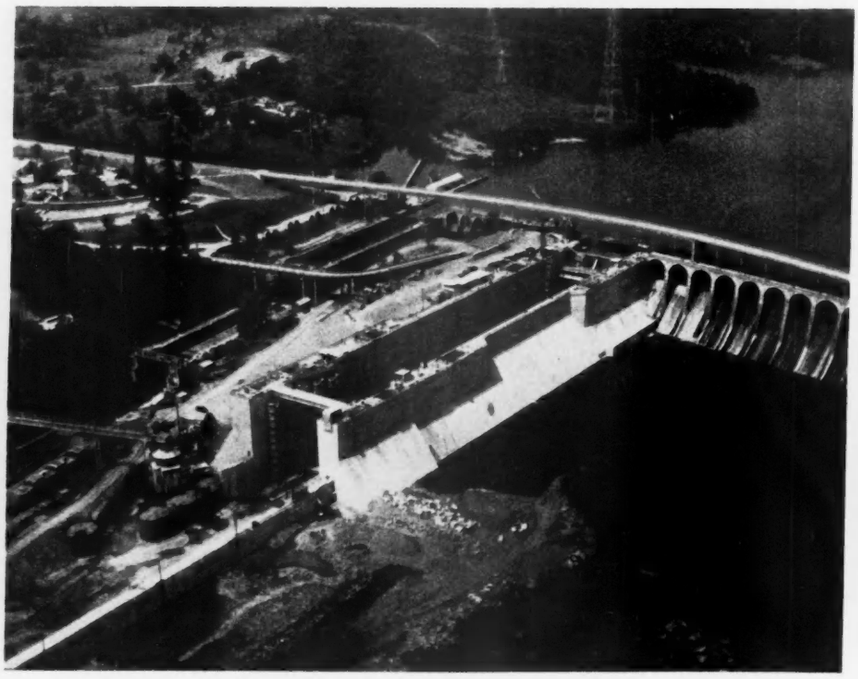


Fig. 6—Aerial view of the Wilson dam lock approaching completion, with new high-level road crossing the lock area

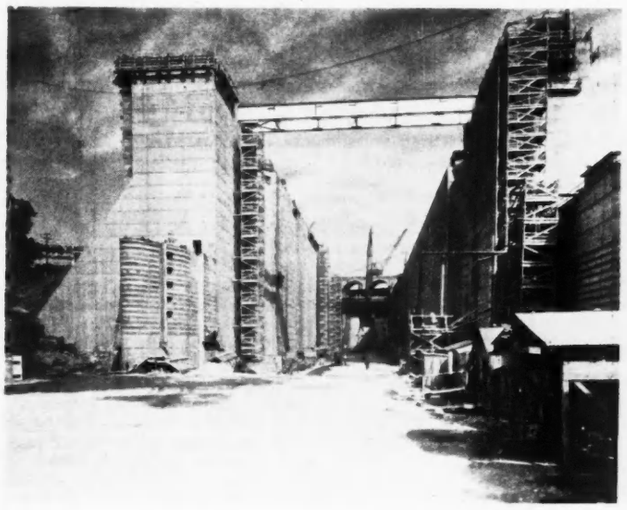


Fig. 7—Upstream view of 600ft long by 110ft wide Wilson dam lock chamber

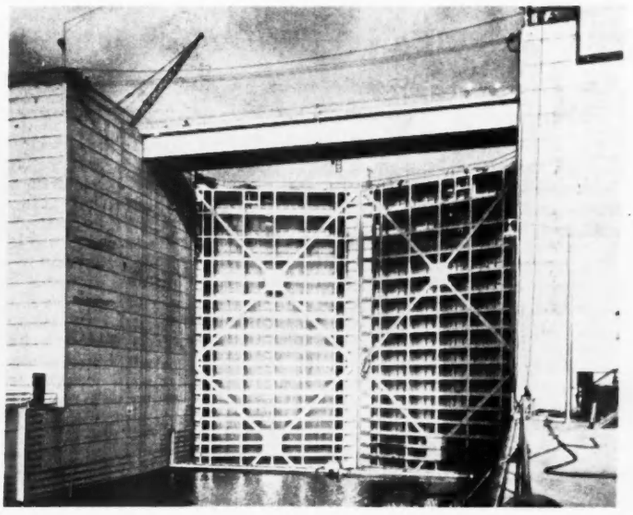


Fig. 8—Double-leaf mitre gate, 117ft high, installed at the downstream end of the chamber

culvert extending the length of the chamber in each wall. These two culverts terminate upstream at bellmouth intakes, 15ft by 23ft, in the dam face ; downstream they make a 90 deg. turn and discharge into the dam spillway channel. Tainter gate valves, at both ends of each culvert, control the flow to and from the ports of the lock-floor lateral system. Final filling can be accelerated by lowering the upper gate to permit spilling into the chamber, while supplementary final emptying will be accomplished through ports under the lower gate. The latter is necessary because the water level in the canal averages 5ft below the river level at the point of discharge. Filling takes about twelve minutes, and the full locking cycle an average of forty-five minutes.

The downstream guard walls are of conventional design. However, the upstream guard wall, 555ft long, is a floating reinforced concrete boom similar to that in successful use at the Kentucky Dam. A high-level bridge spans both the new and the old locks, thus eliminating traffic interruptions on the river and on the dam roadway. The canal alignment has been altered to provide a better sailing line with respect to the railway and highway bridges downstream. This involved by-passing the existing downstream canal lock and dam and required deepening of the present lower tandem lock chamber and the canal by 10ft.

The construction programme, which began in July, 1956, proceeded according to a critically timed schedule which permitted a minimum of delay to traffic on the roadway over the dam and virtually no interruption to navigation. The chief operations involved were the construction of the new lock chamber, including existing spillway alterations ; excavation for and maintenance of a temporary canal while the existing canal was being deepened ; realignment of the canal at the downstream end ; erection of a high-level bridge over the new and existing locks, and deepening of the existing lower lock chamber so that the tandem lock can function as an auxiliary unit without the 10ft of lift now provided at the canal lock.

Very limited space was available for the construction plant. The concrete mixing plant, with three 2-cubic-yard tilting mixers, was situated just downstream from the land wall of the new lock. It was supplied with graded aggregates by conveyor from a 50,000-ton storage area located in a small ravine adjacent to the main construction plant. The concrete mixes were specially designed and tested to utilise limestone aggregates and fly ash supplied from the Colbert steam power station. From the construction plant area on the bluff to the floor elevation of the new lock, trucks and other heavy equipment had to drop 120ft in a horizontal distance of only 800ft. To accomplish this, 1950 lineal feet of bridge and roadway were required to obtain a suitable grade. The through-truss span bridge crossed the existing lower lock chamber on a 5 per cent grade at an angle of 78 deg., and had a navigation clearance of 52ft. On the same grade, a timber trestle then made a 68 deg. turn upstream and connected with two steel trusses, almost parallel, to the new lock which descended on a 7 per cent slope to a rock-filled crib abutment and roadway. The roadway made a complete reverse turn and continued downstream on a 5 per cent grade into the work area.

Eleven closely-timed cofferdam changes were necessary for the new lock construction and to permit deepening of the upper canal and the old lock areas. In addition, seven temporary or permanent dykes were required to allow canal deepening, to make canal alignment changes at the downstream end and to maintain navigation while this work proceeded. The cofferdam for the main lock was designed as a standard cellular steel sheet-pile structure, but difficulty in obtaining sheet-piling necessitated the substitution of a timber rock-filled crib section 200ft long from the spillway and across the apron of the existing dam. In the remaining section there were twenty-eight sheet-pile cells, each 36·6ft in diameter and about 38ft high. The cell farthest downstream was tied to the existing concrete guard wall by a sheet-pile cut-off wall supported by berms of clay and rock. The gravel-filled cofferdam cells were grouted on the river side and backed up on the lock side by riprap. The erection of the main cofferdam on ledge rock was complicated by the presence of large limestone slabs, some containing up to 100 cubic yards and weighing 200 tons. These had been displaced during high-water discharges and deposited in piles and windows below the dam. Drilling and blasting were required to reduce these slabs to a size that could be handled by power shovels. In January and February, 1957, the cofferdams safely passed the Wilson dam flood record, involving a flow of 372,000 cusecs. Rock excavation for the new lock, totalling about 200,000 cubic yards of a shaly limestone, was completed on schedule in eight months, utilising conventional equipment and carbide-tipped tool bits. During the fifteen-month concreting operation, over 375,000 cubic yards were placed. Concrete placement averaged 1800 cubic yards per day, with 2100 cubic yard peaks while working in big blocks. Concreting was done on the two night shifts, the day shift being reserved for form changes and other construction. The passage of water through the dam to fill the lock presented a special construction problem. Two passages, one in each lock wall to supply the filling culverts, required the removal of the dam concrete without disturbing the old structure. It was possible to remove part of the concrete by an open shooting procedure on the downstream face. However, stability considerations for the old dam limited this to about 16ft of the total 42ft cut.

Before further tunnelling could be carried out, it was necessary to place the concrete for the upper gate sill to approximate final elevation and

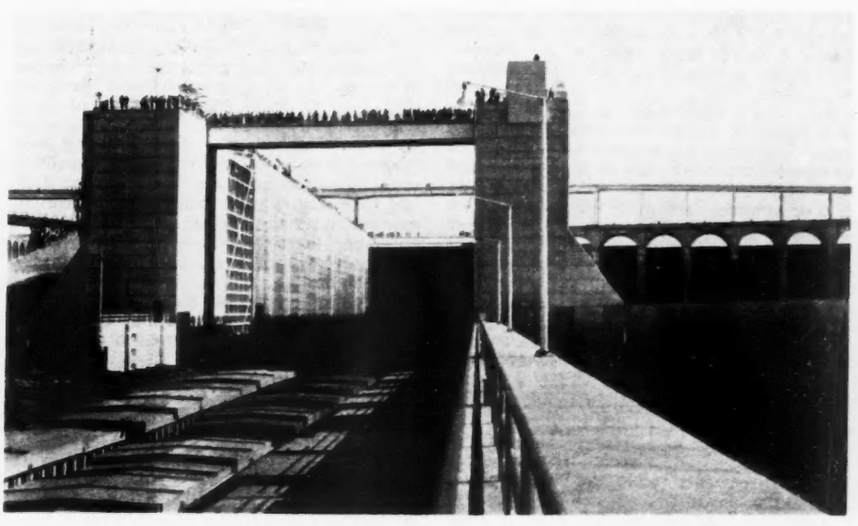


Fig. 9—First tow of barges passing through the lock in November, 1959

THE AMERICAN SCENE *(Continued)*

to concrete the lock walls to above lake level. The lock walls were built up at the back of a floating bulkhead regularly used for gate repair. The sill and wall blocks loaded the spillway, in addition to stabilising the spillway piers against the horizontal pressure of the bulkhead upstream. The tunnel cut, 19ft by 27ft, or 15ft by 23ft after lining with concrete, removed about one-fourth of the dam volume in that section.

To seal off the Wilson reservoir while culvert tunnelling and concreting operations were under way, a 200-ton floating bulkhead, 46ft by 74ft, was built of high-strength steel plate. This bulkhead was a 3ft deep, all-welded, cellular structure whose sides and bottom fitted against the upstream face of the dam. Because of the rough and irregular surface of the dam concrete, it was necessary for a diver, using a series of vertical tight-wires, to plot the configuration of the dam face. From this information sealing details were worked out, using shaped timbers and rubber seals. The bulkhead was positioned by flooding the three lower compartments, thus turning it to a vertical position. It was then sunk to the right depth in front of the culvert opening and pulled tight by cables. Water was pumped out from behind it to a point just below the spillway crest. The spillway gate was then removed and all water pumped out, thus allowing external water pressure to complete the sealing of the bulkhead. A similar procedure was used at the other culvert entrance.

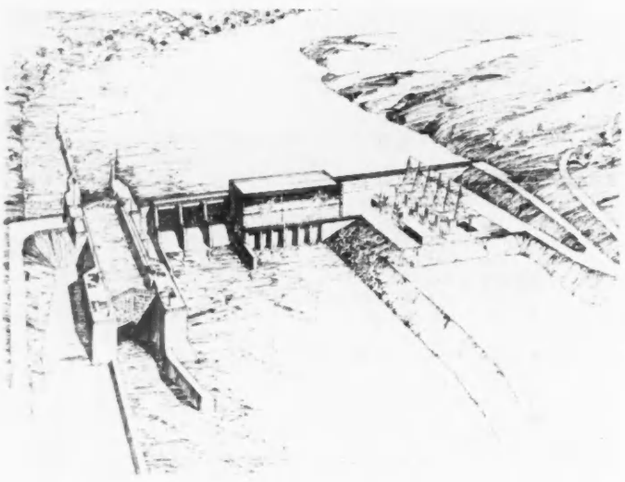


Fig. 10—Drawing of the proposed Melton Hill dam, power station and lock on the Clinch River in Tennessee

With the bulkhead in place and unwatered, a carefully planned and executed tunnelling programme began. Starting from the previously excavated downstream face, three advances of 6ft and one of 6ft to 8ft were made. Before the final 6ft to 8ft advance, the culvert stoplog was positioned to prevent area flooding should the bulkhead become damaged. A timber platform was constructed in the bulkhead to catch falling concrete and a timber mat placed over the culvert entrance area. Line drilling was carried completely through the entire section and the enlarged pilot hole broached through to the bulkhead void. Blast holes, on 18in centres, were drilled to within 18in of the upstream face of the dam. Using only $\frac{3}{4}$ lb of dynamite per hole—$\frac{1}{2}$ lb at the front and $\frac{1}{4}$ lb at the back of each hole—the section was pulled to the pilot hole. The remaining concrete, already cracked by adjacent excavation, was chipped and wedged out. The closeness of both the bulkhead and the dam construction joint made the removal of the last section particularly critical. The high-level bridge over the navigation channels replaces the roadway on the dam and the bascule bridge at the original lock. The removal of the roadway arches and piers in the new lock area was a rather difficult job which had to be closely timed and planned for accomplishment during the four-month period when the roadway was out of service during the erection of the high-level bridge. Four existing roadway arches weighing 1580 tons each and three piers weighing 460 tons each had to be cut into 20-ton to 40-ton pieces, loaded on barges and disposed of upstream in Wilson Lake. Just before the closing of the original roadway in December, 1958, 16ft of the downstream roadway section were removed across all four arches, reducing traffic to one lane. After the road was closed, the remaining 11ft 6in of the roadway section and the 19ft gate section were removed, allowing concrete to be placed in the bridge foundations in this area and in the lock walls up to final grade.

A floating guard boom, 555ft by 27ft, on the spillway side of the lock, guides vessels into the upstream entrance. This concrete boom was built in six sections in an area just downstream from the new lock and floated when the area cofferdam was flooded. The sections were assembled in the lock chamber and towed into the lake above the dam. Assembly, by bolting, was facilitated by the temporary flooding of the compartments to align the boxes. The downstream end of the floating boom was fastened to the lock wall. The upstream end, or nose, of the boom had to have two anchors to hold it in position in over 80ft of water. In the Florence Canal and the temporary canal downstream from the lock, the Massman Construction Company and the Farrell Construction Company moved 3,200,000 cubic yards of material. The temporary canal, 100ft wide, excavated mostly in the dry, permitted navigation to continue without interruption while the contractor deepened the existing 300ft wide Florence Canal and relocated the lower end to by-pass the canal lock of 10ft lift.

Transmission System Construction

About 425 circuit miles of transmission line were constructed during the year, and at the end of the year 11,728 circuit miles were in service in the transmission network. Due to some retirements and minor adjustments, there was a net increase of 359 circuit miles over last year. About 270 miles of 161kV lines were built to transmit power from new steam-electric units into the system. More than 5000 miles of communication services, including telephone, printer telegraph, telemeter, facsimile, pilot relaying supervisory control, and data transmission, were added during the year to keep pace with the growth of generation and transmission facilities. Research and development by T.V.A. has brought about much improvement in carrier transmission on the power lines through so-called "broad-band coupling." This increases the frequency range available for communication and permits more circuits to be used. The printer telegraph circuits have been particularly useful in providing daily information from the steam plants to assist in directing the distribution of large coal receipts. At the end of the year about 25,000 miles of telephone circuit and 38,000 miles of other kinds of communication circuits were in operation. Included in these figures were 23,000 miles of microwave radio circuits.

Project Planning

Investigations were continued during the year on sites for new steam power stations and multiple-use dam projects. At the Norris Hydraulic Laboratory, a scale model was virtually completed for study of the hydraulic features of the proposed Melton Hill Dam. The project is to be built at a site on the Clinch River at the head of Watts Bar Reservoir and would extend the navigation channel on this tributary about 38 miles to Clinton, Tennessee; it would add 72,000kW of installed generating capacity to the power system and take advantage of the storage provided by Norris Dam. A model towboat and barges, operated by wireless remote control, will be used in navigation studies in the model tests at the laboratory.

Limited progress was made on planning studies for three other hydro-electric projects. One was the Austral project on the Hiwassee River below the Appalachian Dam; the second a proposed Fort Loudoun Dam extension which would divert the flow of the Little Tennessee River into the Tennessee above the dam; and the third the Nemo project on the Obed River, a major tributary of the Emory River flowing into Watts Bar Reservoir. An appraisal was made of twenty-six possible sites for future hydro-electric schemes in the Valley, including preliminary estimates of costs, average annual energy, installed capacities, and summaries of principal features. Investigations were continued on possible steam power station sites.

(To be continued)

Space Facts

A POCKET-SIZE handbook entitled *Space Facts* has been compiled and published by the General Electric Missile and Space Vehicle Department. It includes tables of physical data on the sun, its satellites, and their satellites, a discussion of the mechanics of flight out of, and into, the earth's atmosphere, and a study of human characteristics and tolerance to abnormal atmospheres, acceleration, radiation, and impact. The treatments of navigation, guidance, and communications include a nomogram deriving transmitter power from bandwidth, noise level frequency *et al.* for ranges up to 10^8 nautical miles, i.e. one earth radius or Astronomical Unit.

Copies are available from Product Information, Missile and Space Vehicle Department, General Electric Company, 3198, Chestnut Street, Philadelphia 4, Pennsylvania.

Rare Earth Metal Investigated

PRODUCTION of a pound of scandium, an extremely rare metal, by Union Carbide, marks the first time that such a "large" quantity of scandium has ever existed in one place at one time. The accomplishment also marks the completion of the first of two contracts with Materials Laboratory, Air Research and Development Command and the Air Material Command of the United States Air Force at Wright Air Development Centre. This contract called for 1 lb (0·45 kg) of scandium of at least 99 per cent purity.

The material is in the form of two discs of scandium about $3\frac{1}{8}$in (7·9cm) in diameter and $\frac{3}{4}$in (19·1mm) thick, whose 99 per cent purity met the United States Air Force contract specifications. It has a density comparable to aluminium, but at the same time has a relatively high melting point of 1550 deg. Cent., or about two and a half times the melting temperature of aluminium.

The second contract, already under way, calls for an analysis of the material to study its physical, chemical, and mechanical properties.

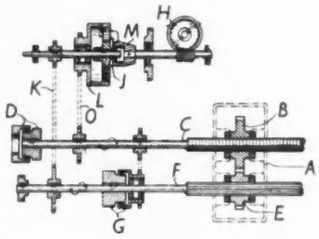
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MACHINE TOOLS

831,762. November 7, 1957.—Differential Drive Mechanism for a Control Drum in a Machine Tool, Seneca Falls Machine Company, Seneca Falls, New York, U.S.A. (*Inventors: Edwin Roy Smith and Constantine Francis Cafolla.*)

This invention relates to means for co-ordinating the angular or rotational movement of a control drum in a machine tool with the linear feed or displacement of a moving member, such as a tool carriage of the machine tool. Such a control drum may be used for controlling the speed or direction of feeding of the carriage or for other analogous purposes. In the drawing are shown primary and secondary drive means for separately or jointly feeding a machine-tool slide or carriage. Referring to the accompanying drawing, a tool carriage *A* rotatably supports a gear nut *B* threaded on a lead screw *C*. The screw is normally held stationary by a magnetic brake *D*. The gear nut is revolved by a meshing gear *E*, slidable on a driven splined shaft *F*. The gear *E* rotates the gear nut *B* and moves the tool carriage along with it. The shaft *F* may rotate the lead screw through sprockets and a chain, one sprocket being driven from the shaft through a magnetic clutch *G*. When the clutch is engaged, the screw *C* will be rotated and the gear nut thus receives an additional axial movement, providing a differential increase in the rate of tool carriage travel. Interlocking means (not shown) determines that when the clutch is closed the brake is automatically released. A control drum *H* is turned angularly in either direction

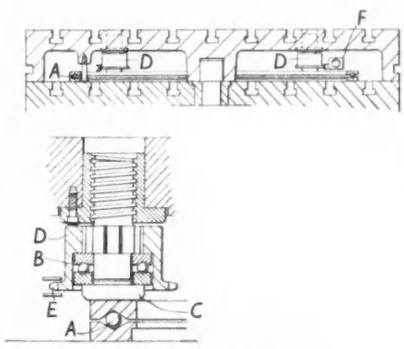


No. 831,762

in predetermined relation to the rotation of the feed shaft and lead screw. Linear movement of the tool carriage may be simply effected by turning the gear nut *B* on the fixed lead screw. Rotation of the gear nut is also transmitted to the sun gear *J* through the sprockets and chain *K*. The sun gear casing *L* is normally held from rotation by the brake *D* and the sun gear rotates the arm *M* and worm to turn the worm gear and drum *H* at a proportional speed. For faster carriage travel, the lead screw is itself rotated and imparts an additional axial movement to the nut *B* and carriage. Such rotation of the lead screw acts through the sprockets and chain *O* to rotate the casing *L*, and thus to superpose additional rotational speed on the drum to correspond to the increased speed of tool carriage travel. The speed of rotation of the drum is thus at all times co-ordinated with the speed of travel of the carriage, and this proportional relation between linear travel and angular displacement is maintained unchanged by changes in either the speed or the direction of carriage travel. Contact pins in one or more series may be selectively mounted in the drum and may actuate any usual limit switches to effect desired changes in speed or direction of carriage travel or other machine functions. The brake *G* will be released whenever the magnetic clutch *M* is activated and vice-versa.—*March* 30, 1960

830,432. May 29, 1958.—Large Revolving Work Tables of Machine Tools, H. W. Kearns and Co., Ltd., Atlantic Street, Broadheath, near Manchester. (*Inventor: Curtis Albert Sparkes.*)

With existing constructions of revolving work tables, in order to facilitate rotation means are usually provided, at the centre, for lifting the table before and during the rotation. Such central lifting of the table may fail to ensure easy rotation if the table is unevenly loaded. Tilting and distortion of the table are avoided by the present invention, according to which a revolving work table is provided with jointly operable lifting jacks spaced around a circle, concentric with the vertical axis and adapted to bear on a coaxial circular track on a supporting surface of the machine tool. Beneath the revolving table there is supported by bolts a large ball race *A* which is concentric with the central spigot. Four screw jacks are spaced around the underside of the revolving table. As shown in detail each jack has a lifting screw bearing, through a thrust ball-bearing *B*, and a non-rotating shouldered plug *C* on the upper race of ball-bearing *A*. Each lifting screw



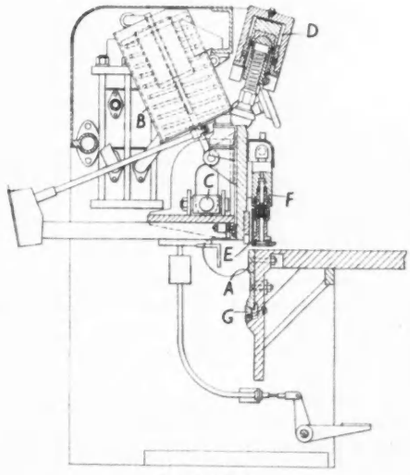
No. 830,432

screws into a bush fitted in the revolving table. The lifting screw of each jack is keyed to a sleeve *D* surrounding its thrust bearing and formed with a sprocket wheel *E*. A chain engages with the sprocket wheels of all four jacks. The ends of this chain are secured to a sleeve nut *F*, traversed along a lead screw spindle, journalled in flanges on the revolving table. By rotating this spindle the four jacks are actuated in unison.—*March* 16, 1960.

GUILLOTINE SHEARS

831,354. August 19, 1958.—Power-Operated Shears, Brookes (Oldbury), Ltd., Brades Road, Oldbury, near Birmingham, and William Henry Laban, 10, South Road, West Hagley, Worcester.

This invention relates to power-operated guillotine shears, and has for its object to provide hydraulically-operated shears in which the angular setting of the movable blade relative to the fixed blade can be adjusted to accord with the work to be performed. In the illustrated example of the invention the horizontal platform at the front of the machine for supporting the sheet or strip to be cut has secured to its rear face a horizontal fixed blade *A* with its upper edge flush with the top of the platform. The



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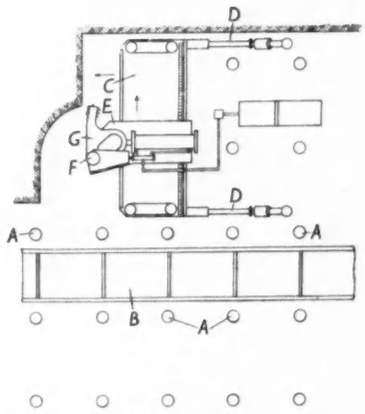
vertically movable slide carrying the upper blade *E* has on its rear face at its ends bearing strips which are held against guides on the frame by a pair of spring units *B* which serve to urge the slide in both an upward and rearward direction. For limiting endwise movement of the slide laterally of the machine there is provided a rod *C* which at one end is mounted within a rubber bush secured to a horizontal plate attached to the rear of the slide and at its other end to the frame. The slide is moved downwards against the action of the spring units *B* by hydraulically-actuated pistons *D* acting on opposite ends of the slide. The axes of the cylinders of these pistons are inclined so that the thrusts exerted act rearwardly as well as downwardly to assist in holding the slide against its guides. Each piston is of hollow cup form at its end to engage a complementary concave seating on the slide, so that the rod is capable of universal angular movement relative to the slide. One or both thrust rods incorporate screw-threaded parts so that their effective lengths can be varied to adjust the angular setting, or rake of the movable blade *E* relative to the fixed blade. By this means the rake of the movable blade can be readily set to accord with the work. In front of the movable slide and above the platform are devices, *F*, for gripping the work. To facilitate the accurate setting of the fixed blade there is formed in the base of the platform a recess having an inclined face with which co-operates one side of a wedge *G* movable by screws. By adjusting the wedge by the screws the blade can be raised or lowered.—*March* 30, 1960.

MINING MACHINERY

831,360. December 20, 1957.—Apparatus for Winning Coal and other Minerals, Stahlwerke Bruninghaus G.m.b.H., Westhofen, Westfalia, Germany.

One example of embodiment of this mineral winning equipment is shown in the accompanying drawings. Parallel to the coal face is a row of props



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A behind which there is a coal face conveyor *B*. A coal winning apparatus according to the invention consists of a frame *C* which can be advanced in a coal cutting direction. At its rear end the frame is coupled to hydraulic cylinders, the outer ends of the pistons *D* of which are fixed to the feet of hydraulic telescopic props clamped in inclined positions between the floor and roof of the mine. Mounted in guides on the frame is a carriage *E* movable along the frame by gears engaging a rack. The carriage carries a bearing for a pivot *F* to which is fixed a cutting tool arm *G*. The arm can be moved to and fro about the pivot over a quarter of a revolution by a hydraulic cylinder. Props at the corners of the frame can be clamped against the roof, so that they take up the roof pressure in the region of the apparatus. At the beginning of the working operation the carriage is situated at the conveyor side of the frame. When the cutter arm is started its swinging movement strips a section of coal of specific thickness from the coal face. The part of the coal face above the cut then breaks down of its own accord. The tool arm is then returned and the carriage moved along the rack by the amount of the required depth for the next cutting cycle. This cycle is repeated step by step until the coal face has been mined-out to a specific depth and the carriage has reached the end of the frame. The carriage is then returned to its initial starting position at the conveyor side of the frame. During this return movement the rear face of the tool arm pushes before it the coal cut and that which has fallen towards the conveyor belt.—*March* 30, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., April 19.—ALDERSHOT AND DISTRICTS BRANCH : Queens Hotel, South Farnborough, Hants, "Silicones in the Electrical Industry," P. R. A. Cherrett, 7.30 p.m.

Wed., April 20.—BIRMINGHAM BRANCH : Visit to Birmingham City Police Headquarters, 7.30 p.m. ★ WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Some Aspects of Electric Arc Welding," J. K. Johanneson, 7.45 p.m.

Thurs., April 21.—READING AND DISTRICTS BRANCH : Visit to H. and G. Simmonds Brewery, Reading, 2.30 p.m. ★ SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, Film and Lecture, "New Light on Niagara," 8 p.m.

Mon., April 25.—BRISTOL AND WEST OF ENGLAND BRANCH : Royal York Hotel, Bath, "The History and Development of Shoemaking in Street," 8 p.m.

BRITISH COMPUTER SOCIETY

Thurs., April 21.—LONDON BRANCH : Northampton College of Advanced Technology, St. John Street, London, E.C.1, "Automation and Uncertainty," Stafford Beer, 2.30 p.m.

Thurs., April 28.—BELFAST BRANCH : 29, University Square, Belfast, Annual General Meeting, 7.15 p.m. ★ SOUTH WALES AND MONMOUTHSHIRE BRANCH : Small Shandon Lecture Theatre, University College, Cardiff, Symposium on "Auto Codes," 6.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Thurs. and Fri., April 21 *and* 22.—1960 NORTHERN CONFERENCE : Southport, "The Problem of Growth."

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., April 21.—MEDICAL ELECTRONICS GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Electro-Physiology," J. G. Nicholls, 6.30 p.m.

Wed., April 27.—LONDON BRANCH : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Electronics in Oceanography," M. J. Tucker, 6.30 p.m.

Thurs., April 28.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting, and Technical Films, 6.30 p.m.

Fri., April 29.—SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, "The Application of Semiconductor Devices in Power Supplies," D. D. Jones, and Annual General Meeting, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Thurs., April 28.—Hoare Memorial Hall, Church House, London, S.W.1, "High Altitude Chambers and Pressure Suits," E. W. Still, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Wed., April 27.—Building Centre, 26, Store Street, London, W.C.1, Film, "Pyrodek Roof Construction," 12.45 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., April 26.—SCOTTISH REGION : Douglas Hotel, Galashiels, Films on "Atomisation" and "Clean Air Act," followed by a Discussion on "Modern Methods of Oil Firing," opened by R. A. Dunlop, 10.30 a.m. and Discussion on "The Utilisation of Small Coals," opened by R. Cleland, 2 p.m. ★ NORTH WESTERN REGION : Engineers' Club, Manchester, "The Working of the Clean Air Act over the Past Twelve Months," J. E. Richards, 2.30 p.m.

Thurs., April 28.—WESTERN REGION : Park Hotel, Cardiff, "Research Towards Improving Mechanisation and Automatic Control in Industrial Coal-Fired Boilerhouses," G. G. Thurlow, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., April 25.—BIRMINGHAM CENTRE : Regent House, St. Philip's Place, Colmore Row, Birmingham, Film Show, 6 p.m. ★ LEICESTER CENTRE : Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, Annual General Meeting, 7 p.m

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., April 27.—LONDON BRANCH : Constitutional Club, Northumberland Avenue, London, W.C.2, Annual General Meeting, and "Foundry Coke—Production and Utilization," J. P. Graham, and L. W. Bolton, 7 p.m. ★ SOUTHAMPTON SECTION : Technical College, St. Mary's Street, Southampton, Annual General Meeting, and Lecture and Film on "Dust Extraction and Dressing," W. B. Lawrie, 7.30 p.m.

INSTITUTE OF FUEL

Wed., April 27.—LONDON BRANCH : Institution of Civil Engineers, Great George Street, London, S.W.1, Presidential Address, 5.30 p.m.

Thurs., April 28.—LONDON BRANCH : Connaught Rooms, London, W.C.2, Annual General Meeting, 11.30 a.m. ★ EAST MIDLAND SECTION : Gas Showrooms Lecture Theatre, Nottingham, Annual General Meeting and "Nuclear Power—The New Power Stations," G. T. Shepherd, 6.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., April 25.—WEST OF ENGLAND SECTION : Small Engineering Lecture Theatre, The University, University Walk, Bristol, 8, Films, "An Introduction to the Heat Engine"; "British Adventure," and "Journey from the East," 7.30 p.m.

Tues., April 26.—The Memorial Building, 76, Mark Lane, London, E.C.3, Annual General Meeting, 5.30 p.m.

INSTITUTE OF METALS

Wed., April 27.—METAL PHYSICS COMMITTEE : 17, Belgrave Square, London, S.W.1, "Deformation and Fracture of Ionic Crystals," J. Washburn, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., April 22.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Economics of Ship Routing," G. L. Hansenn and R. W. James, 5.15 p.m.

INSTITUTE OF PETROLEUM

Thurs., April 21.—LONDON BRANCH : 61, New Cavendish Street, London, W.1, "The Problem of Air Pollution," S. R. Craxford, 6 p.m.

INSTITUTE OF SHEET METAL ENGINEERING

Tues., April 26.—SOUTH-WEST BRANCH : Department of Engineering, The University, Bristol, Forum, "Future Developments in the Steel Industry," 7 p.m.

INSTITUTE OF WELDING

Wed., April 20.—NORTH LONDON BRANCH : 54, Princes Gate, London, S.W.7, Annual General Meeting, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 26.—Great George Street, Westminster, London, S.W.1, "Design, Fabrication and Erection of the Ganga Bridge," S. G. Savarkar, S. Turley, J. Williams and R. J. C. Tweed, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., April 19.—SOUTH-EAST SCOTLAND SUB-CENTRE : "The Application of Irradiation in Industry," M. C. Crowley-Milling, 7 p.m. ★ OXFORD DISTRICT BRANCH : Council Chamber, Town Hall, Oxford, Joint meeting with the Institution of Production Engineers, "Power Factor Correction of Industrial Electricity Supplies," R. O. M. Powell, 7 p.m.

Wed., April 20.—SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Some Considerations in the Application of Power Rectifiers and Convertors," J. P. McBreen, 6 p.m. ★ SOUTHERN CENTRE : Farnborough Technical College, Boundary Road, Farnborough, Hants, "Machine Translation of Languages," A. D. Booth, 6.15 p.m.

Thurs., April 21.—SOUTH MIDLAND CENTRE : General Electric Company, Ltd., G.E.C. Ballroom, Telephone Works, Stoke, Coventry, "The Jodrell Bank Radio Telescope," C. M. Kington, and Film, "The Inquisitive Giant," 7 p.m.

Fri., April 22.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Broadening University Courses," opened by H. E. M. Barlow, 6 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : Duncan Hall, Stone, "The Application of Transistors to Line Communication Equipment," H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead, 7 p.m.

Mon., April 25.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, "A Survey of Microwave Techniques for the Transmission of Speech and Vision," K. C. Kao, 6.30 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP : James Watt Memorial Institute, Birmingham, "The Challenge of the Propagation Medium to the Radio Engineer," G. Millington, 6 p.m.

Tues., April 26.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, "An Experimental Transistor-Controlled Component Selection and Testing Machine," T. C. Cardwell, J. R. W. Smith and G. H. King, 5.30 p.m. ★ NORTH MIDLAND UTILISATION GROUP : Leeds and County Conservative Club, South Parade, Leeds, 1, "Silicone Electrical Insulation," J. H. Davis, 6.30 p.m.

Wed., April 27.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "Henri de France Colour Television System," R. Chaste and P. Cassagne, 5.30 p.m. ★ SHEFFIELD SUB-CENTRE : Royal Hotel, Cleethorpes Road, Grimsby, Second Hunter Memorial Lecture, "The Protection of Electrical Systems," H. G. Bell, 7 p.m.

Thurs., April 28.—ORDINARY MEETING : Savoy Place, London, W.C.2, "Radar Observations of Birds and 'Angels,'" E. Eastwood, 5.30 p.m.

Fri., April 29.—SOUTH MIDLAND EDUCATION DISCUSSION CIRCLE : College of Technology, Gosta Green, Birmingham, Discussion on "The Generalized Analysis of Electrical Machines," opened by J. G. Henderson, 6 p.m.

Sat., April 30.—LONDON GRADUATE AND STUDENT SECTION : Visit to Bankside Power Station, London, S.E.1, 10.30 a.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., April 27.—Midland Hotel, Bradford, Films, "From Strength to Strength," and "1000 Miles in Fourteen Hours," 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., April 26.—GENERAL MEETING : Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Steel Wheels and Tyres," C. F. Ryan and B. B. Hundy, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Wed., April 20.—SOUTHERN GRADUATES' SECTION : Visit to Witney Blankets, Witney, Oxon, 2.30 p.m. ★ COVENTRY GRADUATES' A.D. CENTRE : Craven Arms, High Street, Coventry, "Trends in Transmission, 1900-1960 ?" B. C. Mills, 7.30 p.m.

Thurs., April 21.—MIDLAND BRANCH : Matthew Bolton Technical School, Suffolk Street, Birmingham, Repetition of the James Clayton Lecture, "The Future of Air Breathing Engines in Aviation," S. G. Hooker, 6 p.m. ★ EASTERN GRADUATES' SECTION : Crown and Anchor Hotel, Ipswich, Annual Meeting of Colchester/Ipswich/Norwich Panel, 7.30 p.m. ★ YORKSHIRE GRADUATES' SECTION : Hotel Metropole, Leeds, Annual General Meeting, and "Automatic Control of Machine Tools," O. S. Puckle, 6.30 p.m.

Mon., April 25.—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "A Comparison of Anglo-American Productivity Figures," 6 p.m. ★ MIDLAND GRADUATES' SECTION : Engineering Centre, Stephenson Place, Birmingham, "Problems of Erosion and Corrosion in Wet Dust Extraction Plant," A. B. Arnison and "Marine Lighthouse Design and Construction," J. A. Fletcher, 7 p.m.

Tues., April 26.—LONDON GRADUATES' SECTION : Visit to E.M.I., Ltd., Hayes, 2 p.m.

Wed. April 27.—LONDON BRANCH : 1, Birdcage Walk, Westminster, London, S.W.1, Annual Meeting and Film Show, "The Rival World," 6 p.m. ★ WESTERN A.D. CENTRE : Royal Hotel, Bristol, "Car Engines," S. S. Tresilian, 6.45 p.m. ★ EASTERN GRADUATES' SECTION : Visit to British Timken, Duston, Northampton, 7 p.m.

Thurs., April 28.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "Papermaking," T. J Davies, 6.30 p.m.

Fri., April 29.—COVENTRY GRADUATES' A.D. CENTRE : Visit to Coventry Climax Engines, Ltd., 6 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., April 21.—Geological Society, Burlington House, Piccadilly, London, W.1, Discussion of the papers, "Production of Thorium Metal," A. R. Gibson and J. R. Chalkley; and "Genesis of Marine Sedimentary Iron Ores," H. Borchert, 5 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., April 20.—KENT BRANCH : Railway Hotel, Dartford, "Ferrous and Non-Ferrous Welding," 7 p.m.

Thurs., April 21.—BLACKBURN BRANCH : Castle Hotel, Blackburn, "Modern Electric Space Heating," W. N. Shires, 7.30 p.m.

Mon., April 25.—WEST AND EAST YORKSHIRE BRANCH : Houldsworth School of Applied Science, The University, Leeds, "The Yorkshire Motorway," J. Michie, and Film, 7.30 p.m.

Tues., April 26.—SOUTH WALES BRANCH : South Wales Institute of Engineers, Park Place, Cardiff, "Heating and Air Treatment in Industry," A. A. Field, 7.30 p.m.

Thurs., April 28.—MERSEYSIDE AND NORTH WALES BRANCH : The Blossoms, Chester, "Selection of Pumps," 7.15 p.m. ★ SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Mechanical Principles of Quarrying Equipment," K. Holland, 7.30 p.m.

Fri., April 29.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Materials Handling—Fork Trucks, &c., Maintenance and Repairs," 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., April 20.—MIDLANDS REGION : James Watt Memorial Institute, Birmingham, Annual General Meeting; and Chairman's paper "Meeting a Challenge," J. Silver, 6.30 p.m. ★ WOLVERHAMPTON GRADUATE SECTION : Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, "Welding of Stainless Steel," J. A. McWilliam, 7 p.m. ★ NORTH MIDLANDS REGION : Conference Room, Peterscourt, Peterborough, "Radio Isotopes in Engineering," W. D. Busbridge, 7.30 p.m.

Thurs., April 21.—SOUTH EASTERN REGION : Royal Commonwealth Society, Northumberland Avenue, Strand, London, W.C.2, "Modern Planning and Progress in the Building Contracting Industry," R. S. Smith, 7.30 p.m.

Sat., April 23.—NORTH MIDLANDS REGION : Welfare Hall, Rolls-Royce, Ltd., Derby, One-day conference, "The Production Engineer in a Changing Economy," 9.30 a.m.

Mon., April 25.—NORTH WESTERN REGION : Great Hall, Manchester College of Science and Technology, Sackville Street Manchester, "Recent Developments in the Design and Construction of Ships," R. V. Turner, 6.30 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., April 27.—SOUTH EASTERN SECTION : Institution of Civil Engineers, Great George Street, London, S.W.1, Annual General Meeting and Two Papers, 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., April 29.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "A Journey from Venice to Dubrovnik," G. V. Rickards, 7 p.m.

OPERATIONAL RESEARCH SOCIETY

Wed., April 20.—Royal Society of Arts, 6, John Adam Street, London, W.C.2, "An Integrated Project for the Design and Appraisal of Mechanised Decision Making Control Systems," K. D. Tocher, 6 p.m.

PLASTICS INSTITUTE

Wed., April 20.—NORTH-EASTERN SECTION : Second Dining Room, Eldon Grill, Grey Street, Newcastle upon Tyne, Annual General Meeting, 7 p.m. ★ WESTERN SECTION : Technical College, Stroud, "Thermosets : New Materials, New Methods, New Problems," J. Butler, 7 p.m.

Sat., April 23.—SOUTHERN SECTION : Visit to Southampton Gas Works, 2.30 p.m.

Fri., April 29.—MIDLANDS SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Fibre Resin Preform Moulding," A. Lewin, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Fri., April 29.—WEST OF ENGLAND BRANCH : New School of Engineering, The University, Bristol, "Precasting in Concrete Framed Construction," J. F. Greinig, and R. C. Westbrook, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Fri., April 22.—AGRICULTURAL AVIATION GROUP : Library, 4, Hamilton Place, London, W.1, Discussion on "Pilot Training," 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Wed., April 20.—QUANTITY SURVEYORS GENERAL MEETING : 12, Great George Street, London, S.W.1, Discussion on "Techniques in Quantity Surveyors' Offices," opened by A. T. Brett-Jones, C. R. King and R. W. Coatman, 6 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., April 20.—49, Cromwell Road, London, S.W.7, Annual General Meeting, and Presidential Address, J. M. Stagg, 5 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., April 21.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, Annual General Meeting, and "Electrode Processes in Primary Batteries," D. H. Collins, 6 p.m.

Fri., April 22.—CORROSION GROUP EDUCATION PANEL : 14, Belgrave Square, London, S.W.1, Conference on "Teaching Corrosion Science to Engineers," 11 a.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., April 26.—CONTROL SECTION : Manson House, 26, Portland Place, London, W.1, Annual General Meeting, and "Some Recent Advances in Industrial Electrical Control Techniques," T. E. Barany, 6.15 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., April 21.—Park Place, Cardiff, Industrial Film Evening, 6.30 p.m.

WORK STUDY SOCIETY

Fri. to Sun., April 22 *to* 24.—Grand Atlantic Hotel, Weston-super-Mare, Working Conference on "Measurement and Management."

Advanced Engineering Courses

The Application of Work Study. UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. The purpose of the course is to examine work study theory and research and its practical application as the direct approach to increasing industrial productivity efficiency, by the more effective employment of existing equipment, materials and personnel. The course will be held from 9.30 a.m., Monday, May 23 until 3.30 p.m., Friday, June 3. Inclusive charge for two-week residential course is fifty-five guineas.

Control Engineering. NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE, Burton Street, Nottingham. A one week's special course, commencing Monday, May 16, at 10.30 a.m. Fee, three guineas.

Postgraduate Course in Nuclear Technology (Chemical), 1960–61. IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. The object of the course is to provide a general training in the chemical, chemical engineering and metallurgical aspects of nuclear technology, interpreted in a wide sense. Thus, in addition to topics relating to nuclear power production such as fuel element technology and the processing of irradiated fuels, a part of the course is devoted to the applications of radioisotopes as tracers and for non-destructive testing, and the possible uses of sources of radiation for inducing chemical reactions of industrial importance. The latter subjects are, therefore, included as a natural development from the basic courses in radiochemistry and radiation chemistry. Satisfactory completion of this course will qualify students for the award of the Diploma of Imperial College (D.I.C.). The Department of Scientific and Industrial Research states that the course is acceptable for the tenure of advanced course studentships. Applications for admission should be made as soon as possible. The fee for the course is £64.

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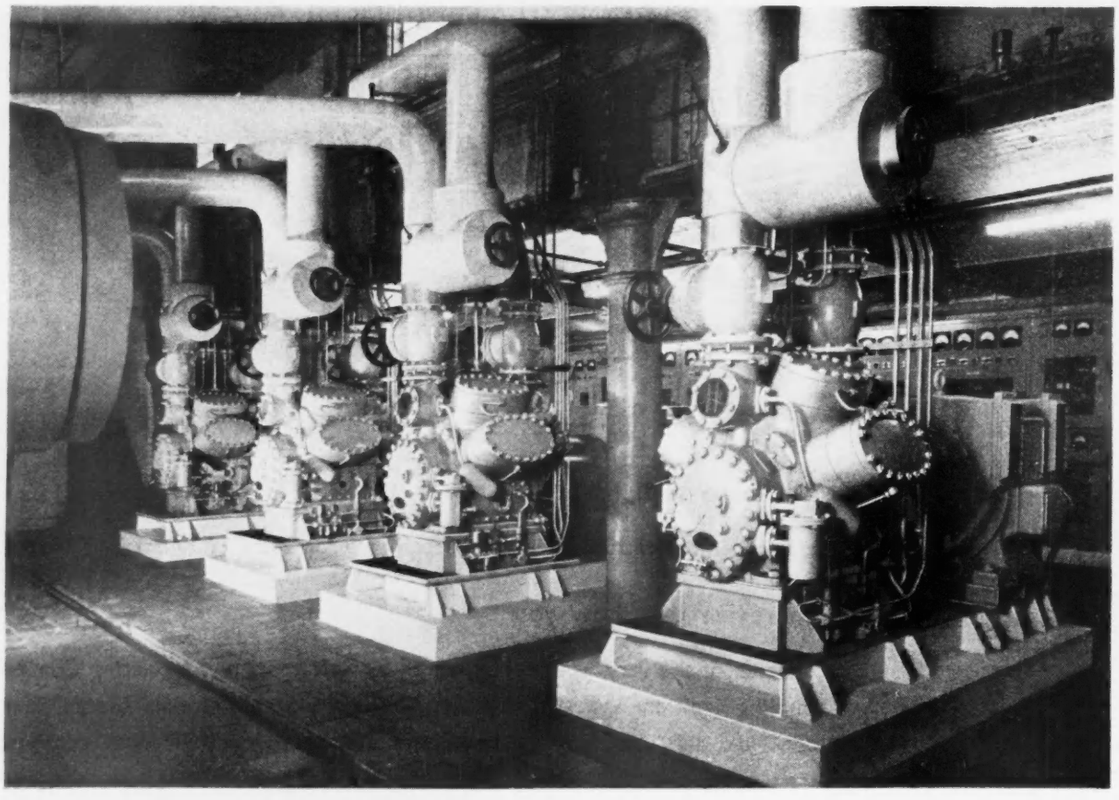

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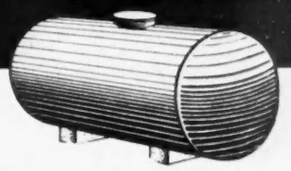

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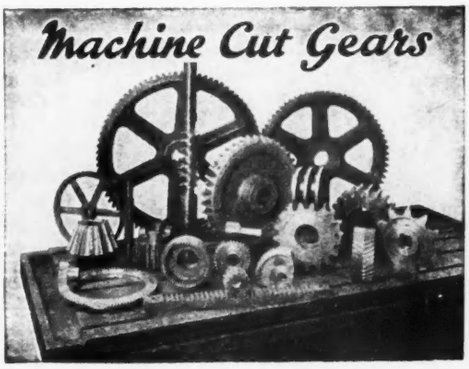

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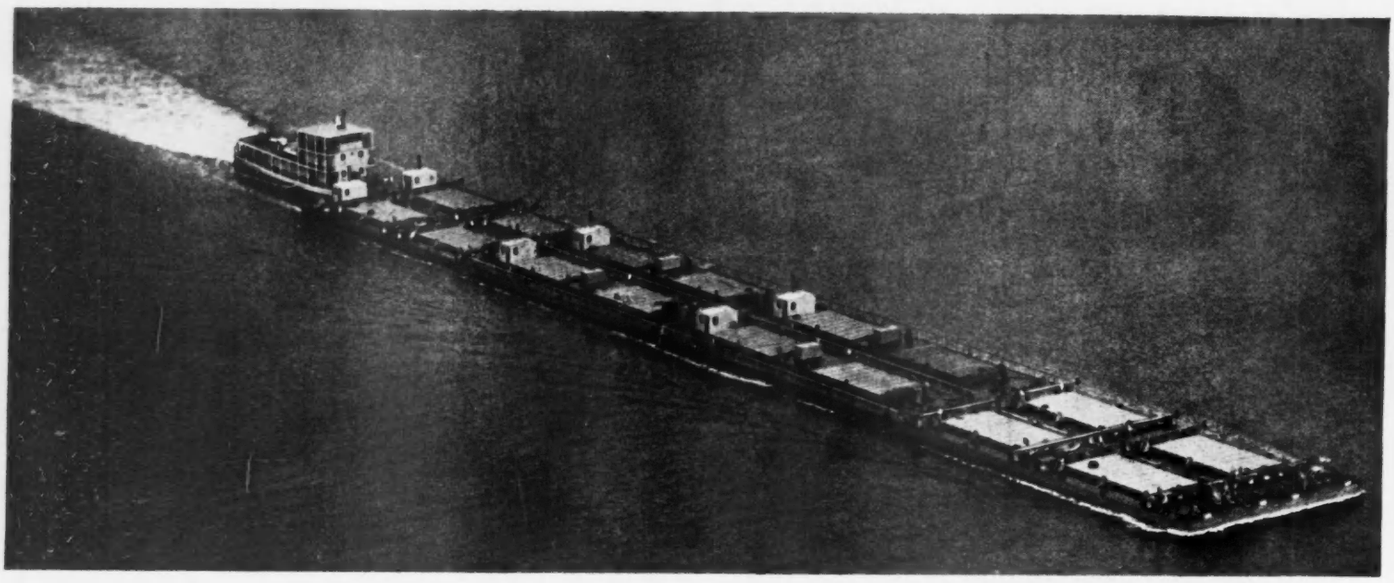

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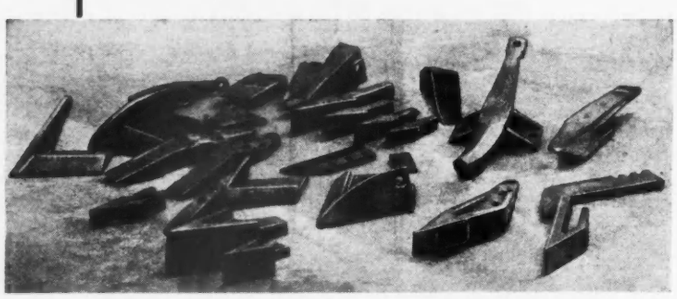

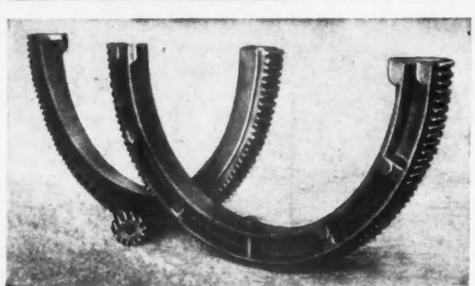

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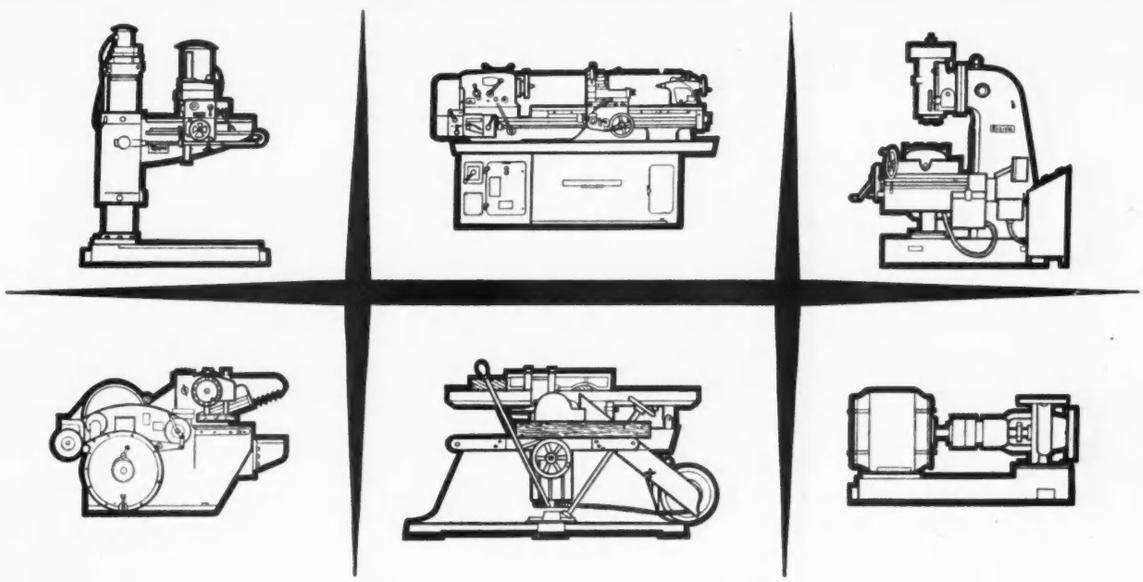

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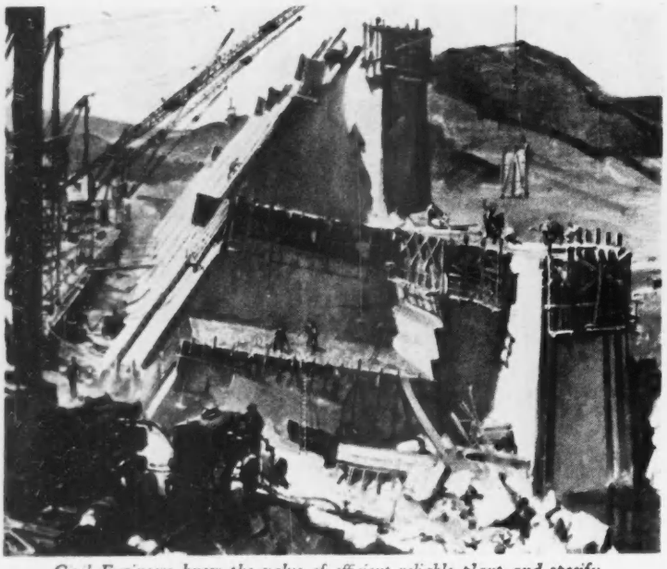

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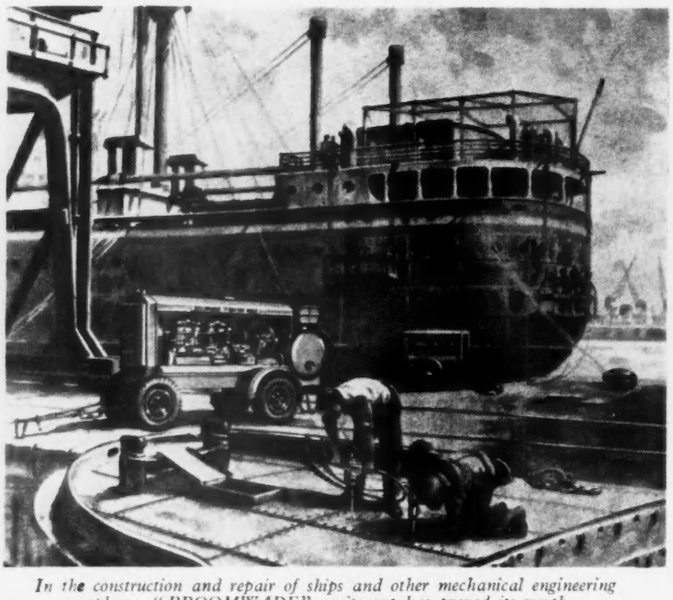

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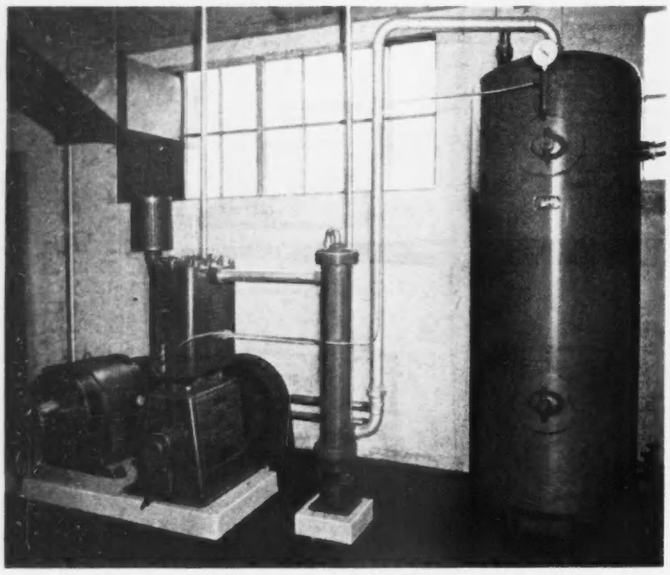
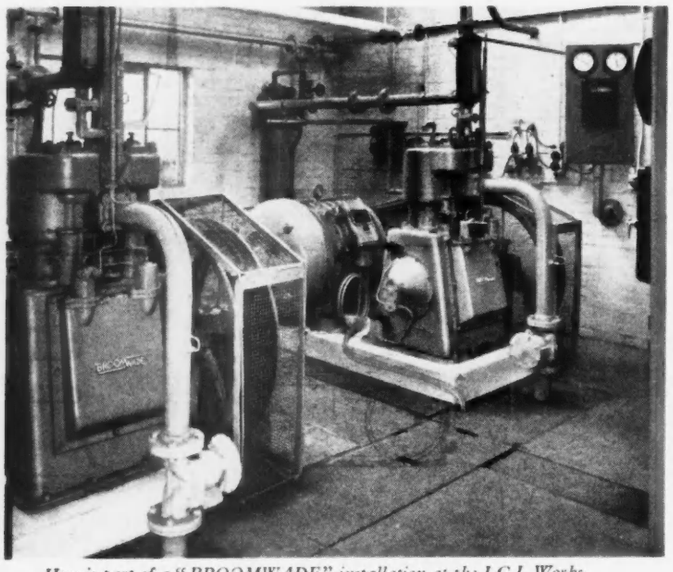


Where oil-free air is necessary, as in chemical, food processing and instrument control, "BROOMWADE" oil-free air compressors are outstanding. Illustrated is an oil-free air compressor installation for Electric Lamp manufacture.



Here is part of a "BROOMWADE" installation at the I.C.I. Works, Slough, where the famous 'Dulux' paints are made.

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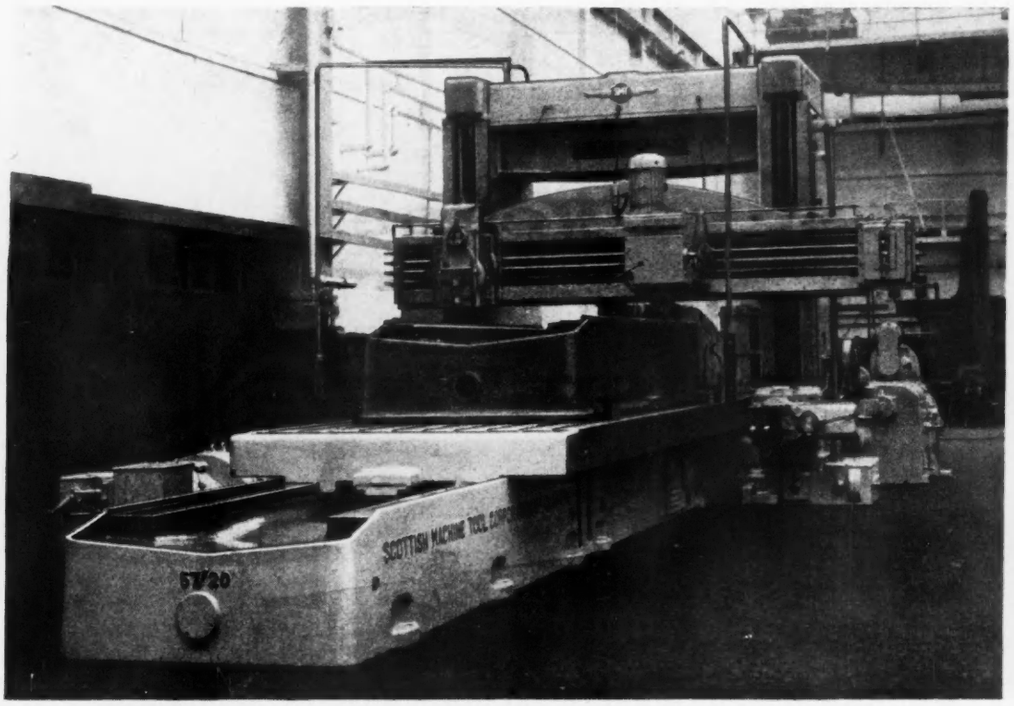

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The illustration shows an 8′ 0″ × 6′ 0″ × 24′ 0″ Planing Machine on test in our Loudon Works, prior to its delivery to our Bennie Works, where it is to be used in the manufacture of our Plate and Bar Working Machinery. In the photograph, a test job is the end bed of one of our Planing Machines.

This Machine, as is the case with all our latest Planers, has the closed loop system of electrical drive, giving cutting speeds up to 220ft. / min. (Higher speeds can be arranged when required.) The reversal and accelerating characteristics of the drive are much improved, giving faster cycle times, with excellent power curves.

The robust proportions of the Machine will be noted, also the bed with its inverted flat ways for easy maintenance and reliable lubrication. All slides are square lipped.

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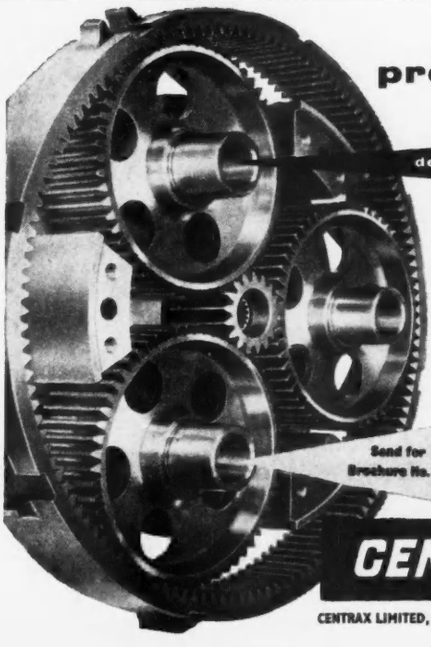

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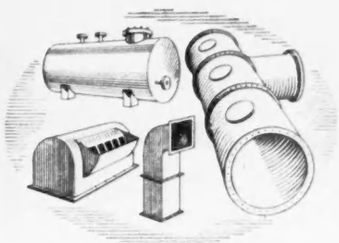

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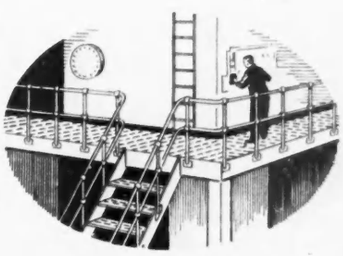

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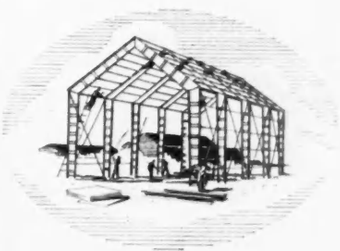

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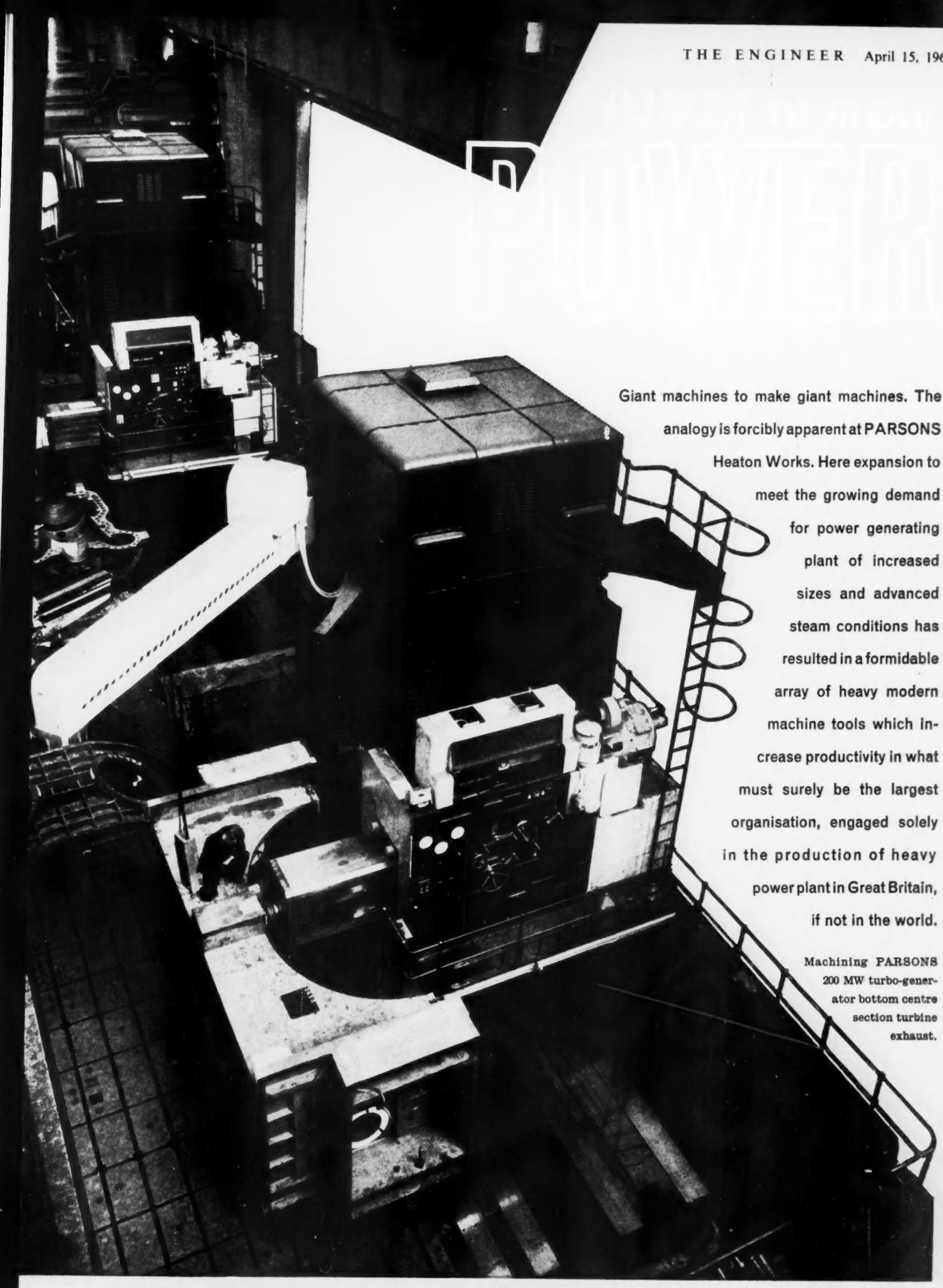

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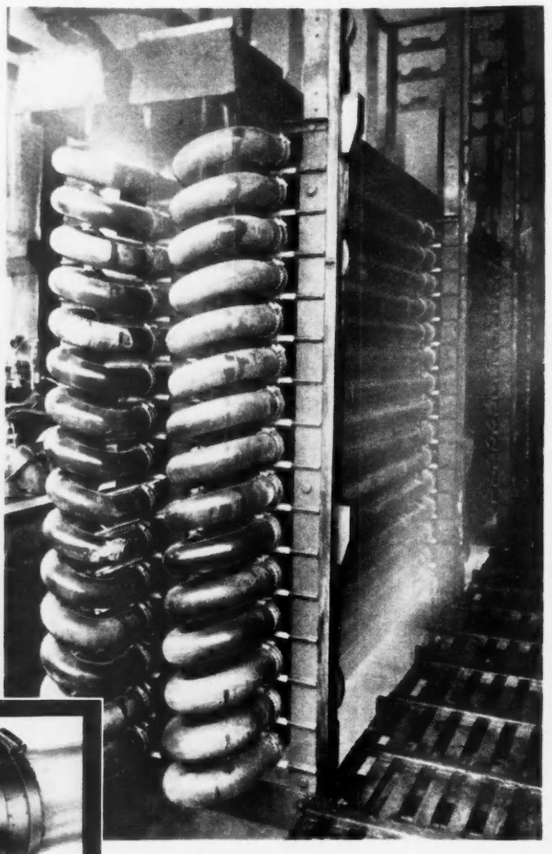

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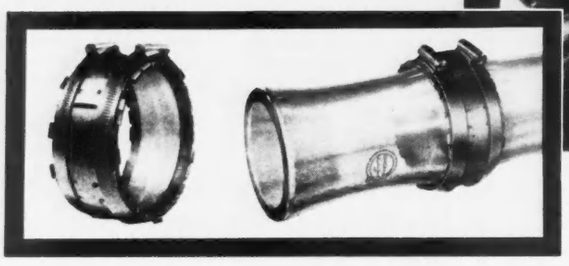

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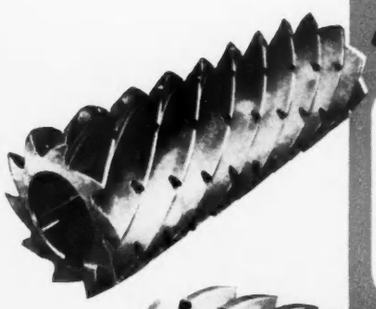

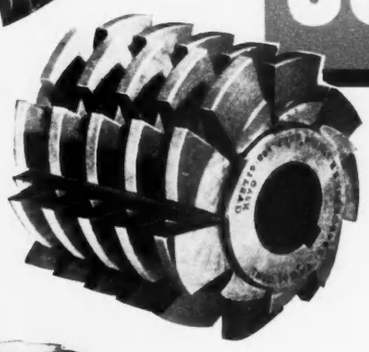

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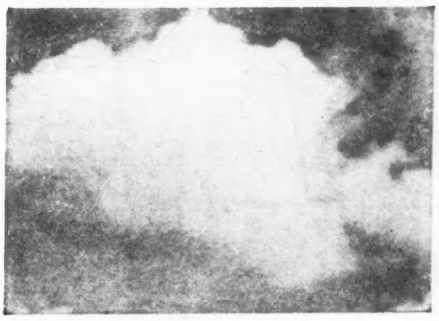

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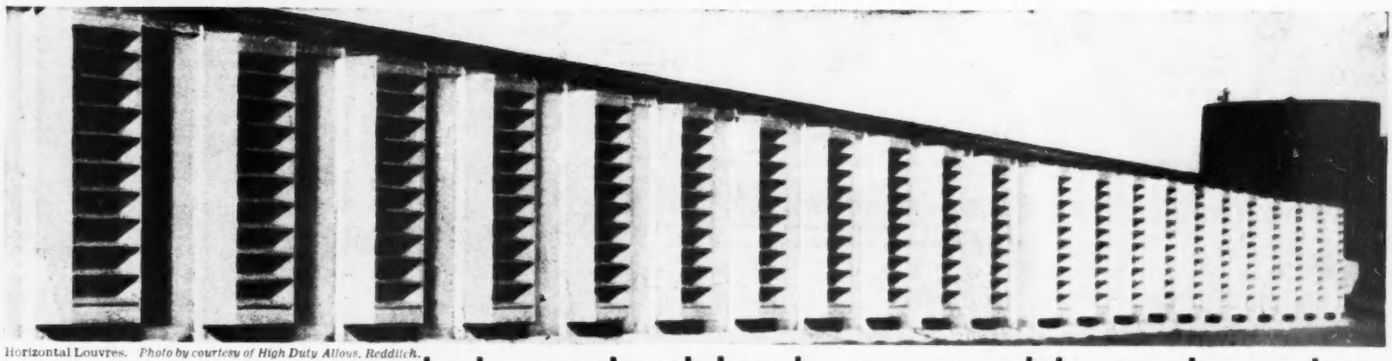

Horizontal Louvres. *Photo by courtesy of High Duty Alloys, Redditch.*

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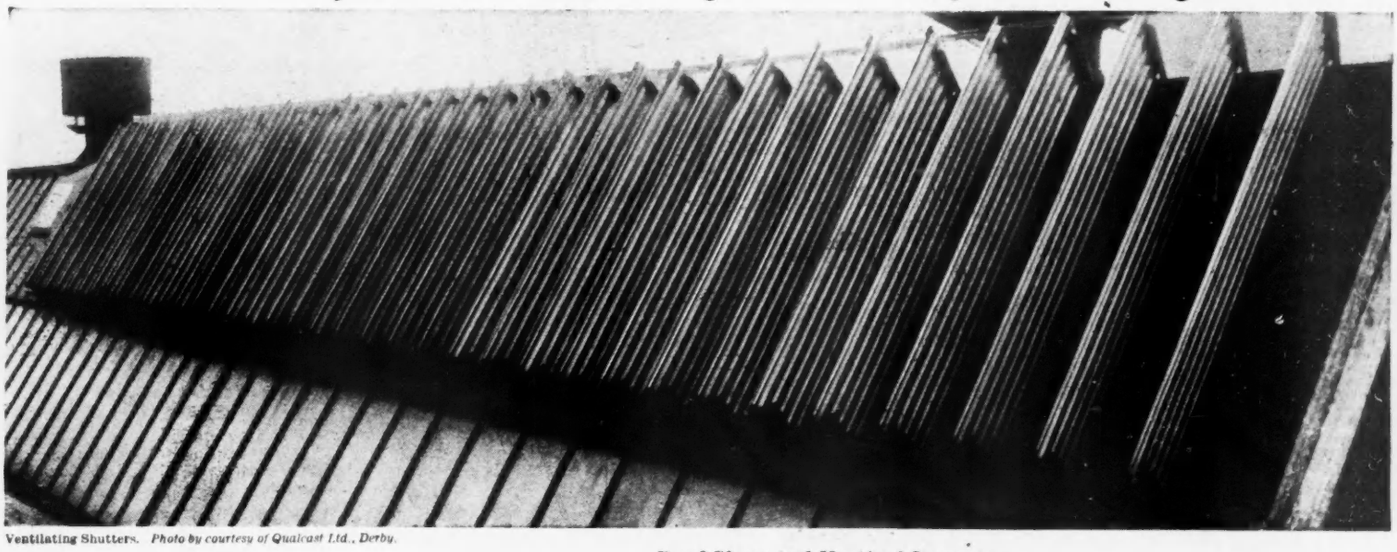

Ventilating Shutters. *Photo by courtesy of Qualcast Ltd., Derby.*

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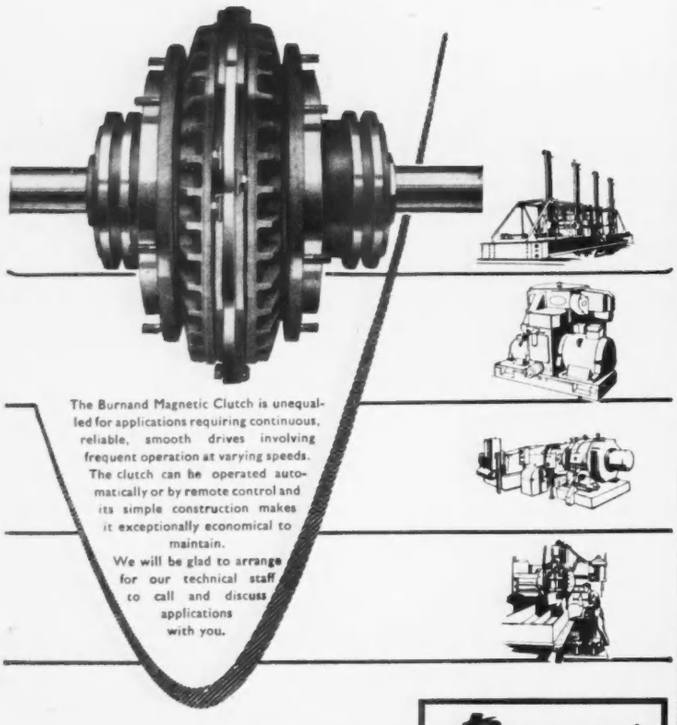

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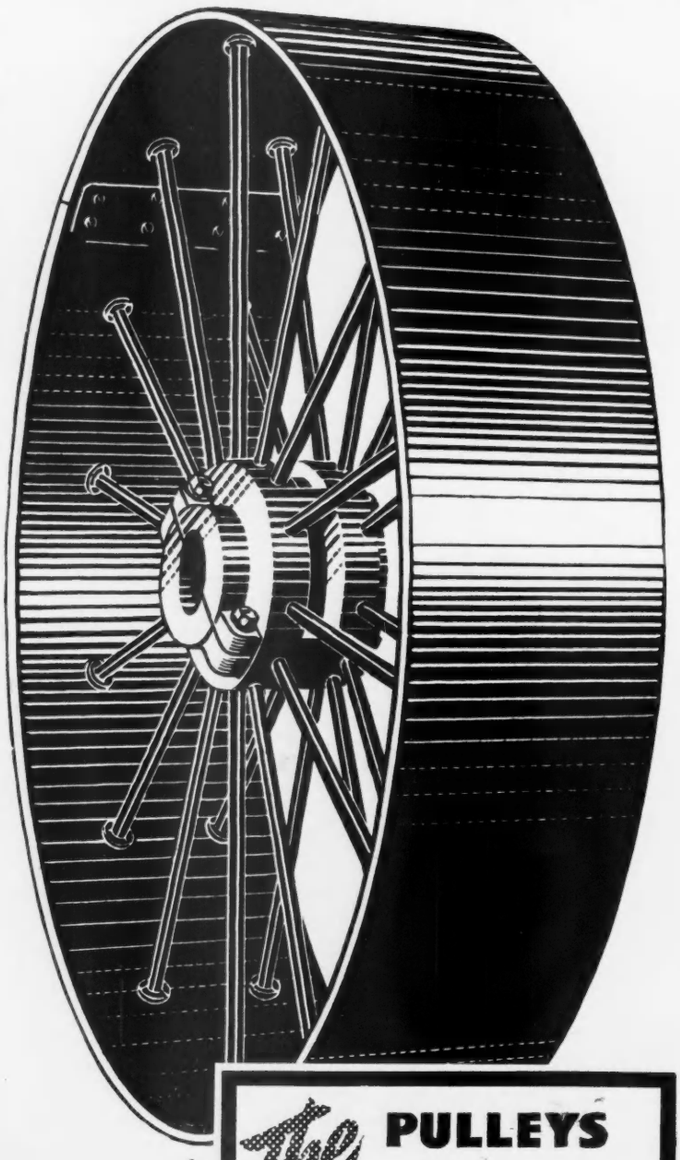

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in any diameter from 6" up. Strong rigid design, substantial machined boss and accurately formed rims ensure minimum wear on belts - and smoother, stronger drive.

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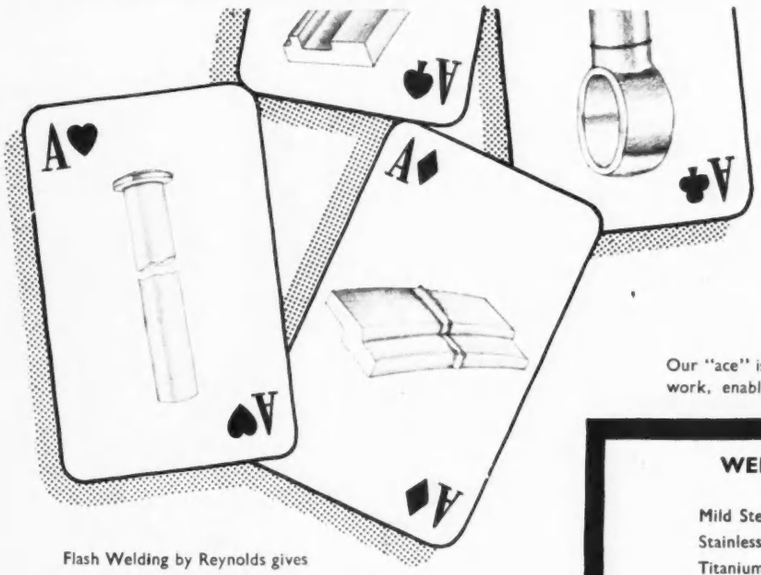

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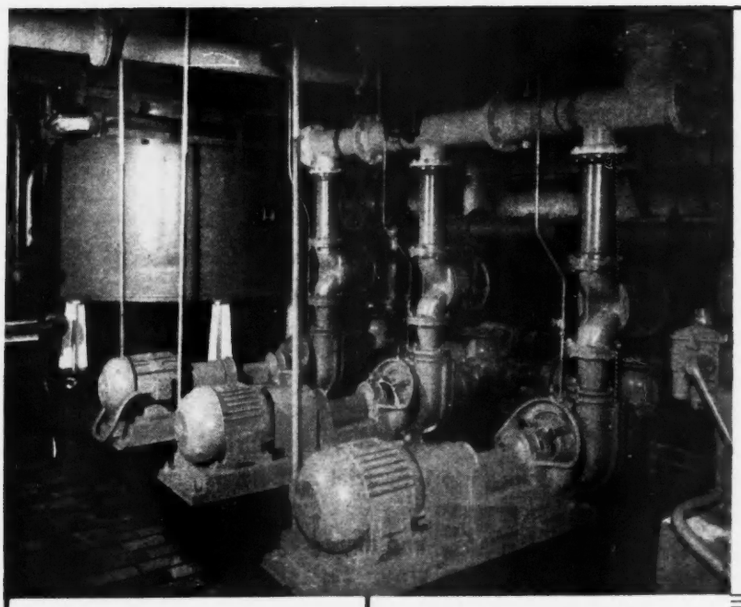

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Chromic Acid and Nickel Solutions for electrolytic plating plants including pumping to filters, etc

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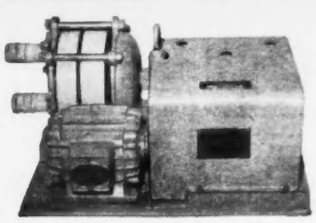
Pumping of demineralised water

(Top left) Large battery centrifugal acid pumps
(Bottom left) Close-up view of diaphragm pump similar to the hand operated unit but arranged for motor drive
(Bottom centre) Hand operated portable diaphragm pump for emptying carboys or tanks and for general duties.
(Bottom right) Portable rotary displacement pump pumping plating solutions in the motor car trade



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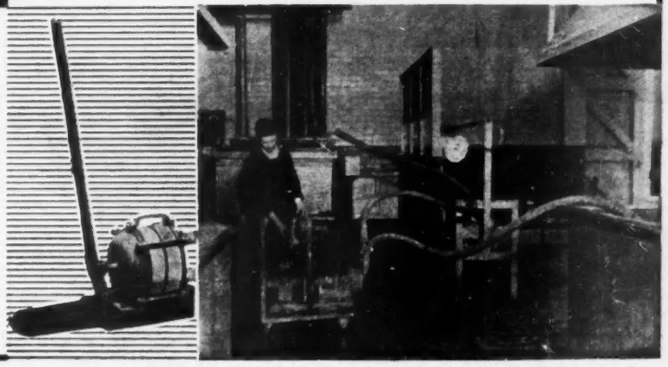

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A tricky question from such a young fellow—at first sight. A V-Belt drive however, is a relatively simple method of power transmission, but it is important to realise that the construction of V-Belts differs enormously. The main reason why most people use T.V. Belts (Turners V-Belts) for industrial duties, is that the strength of a T.V. Belt lies at the neutral axis, which ensures thousands of hours of trouble-free running. To sum up briefly—a T.V. Belt gives improved performance with considerably reduced maintenance costs; childishly simple—but of first importance to the user.

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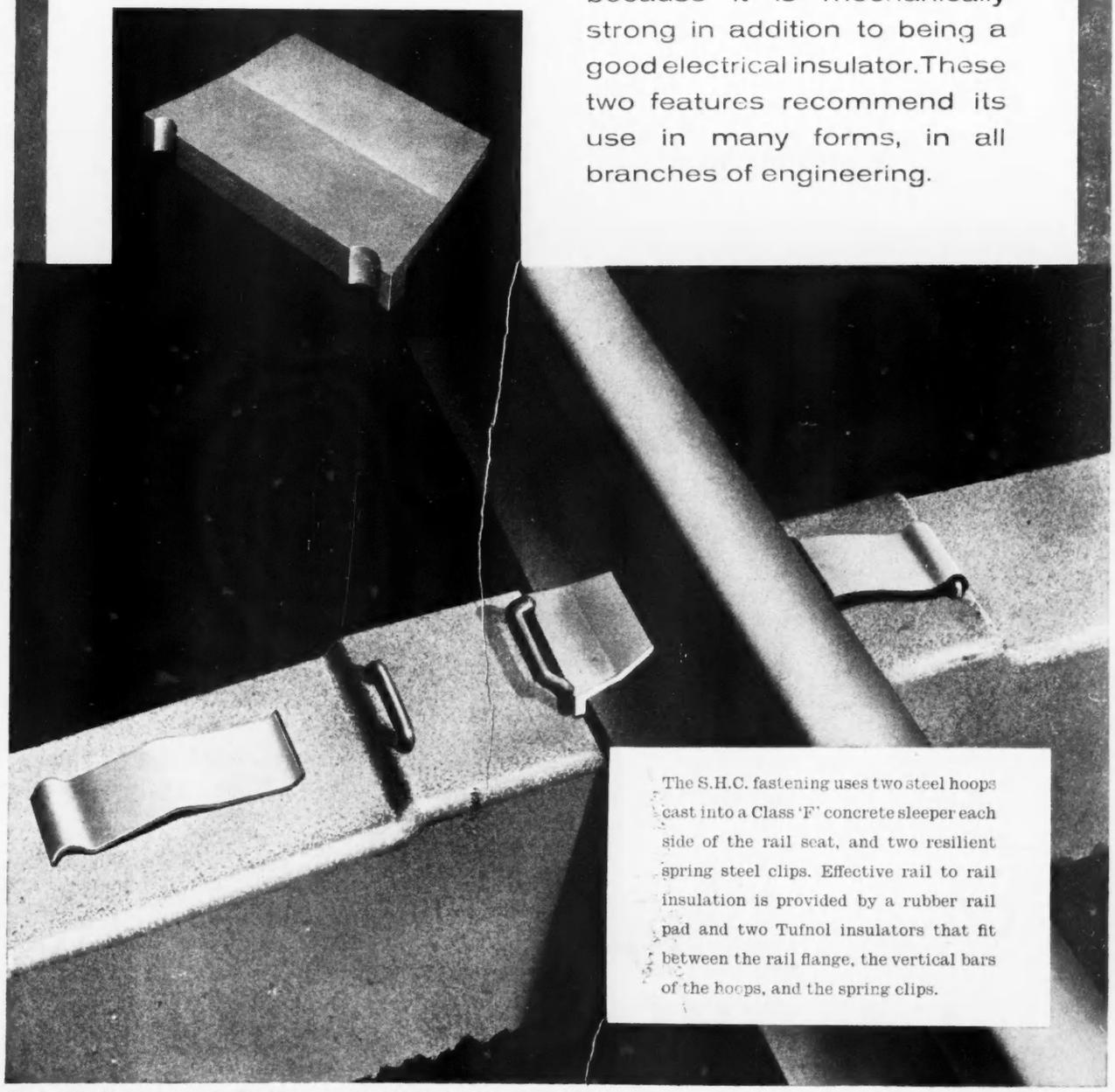

The S.H.C. fastening uses two steel hoops cast into a Class 'F' concrete sleeper each side of the rail seat, and two resilient spring steel clips. Effective rail to rail insulation is provided by a rubber rail pad and two Tufnol insulators that fit between the rail flange, the vertical bars of the hoops, and the spring clips.

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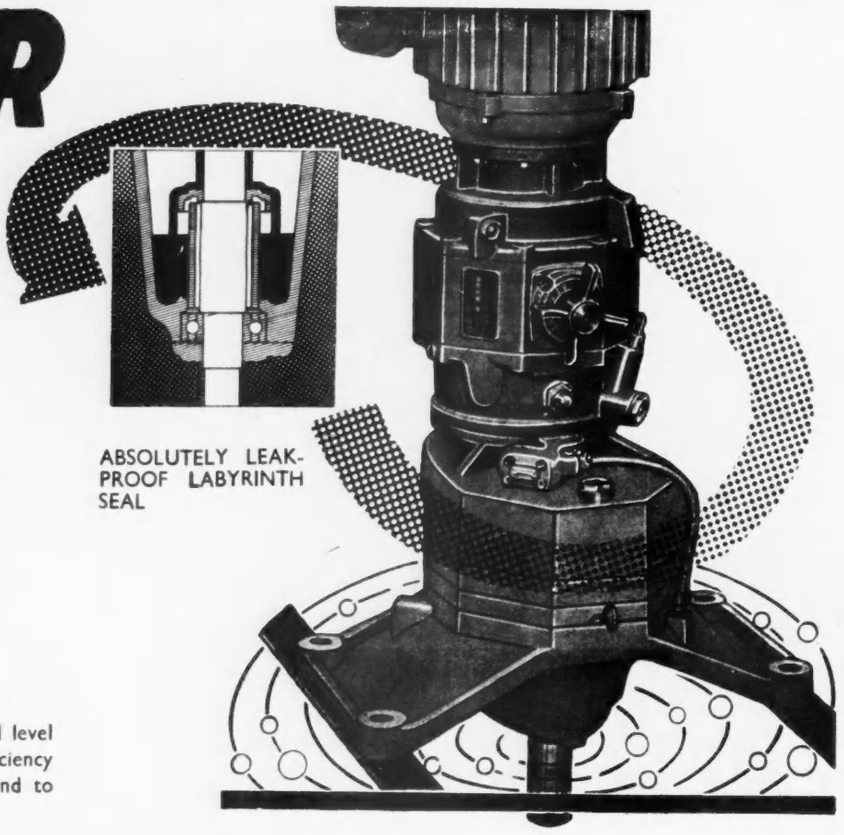

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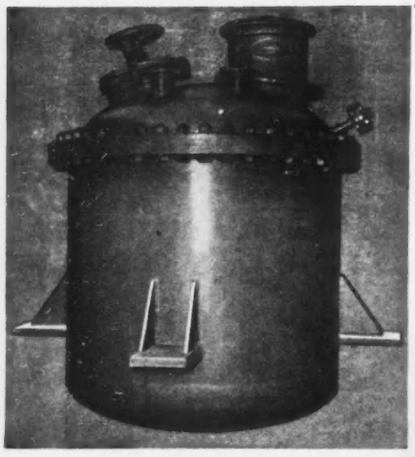

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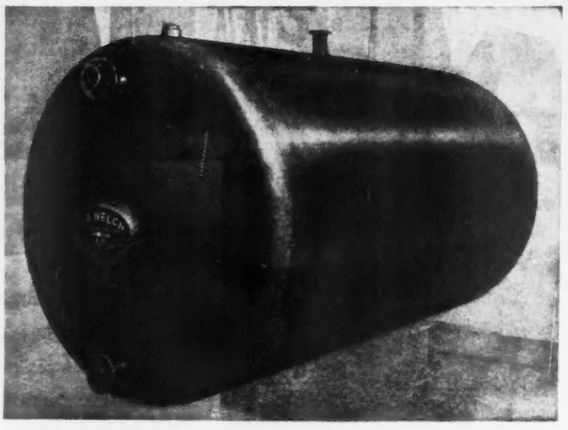

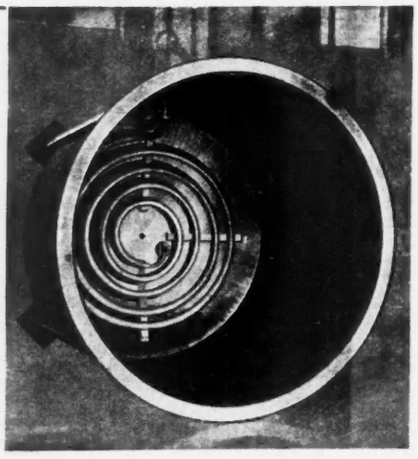

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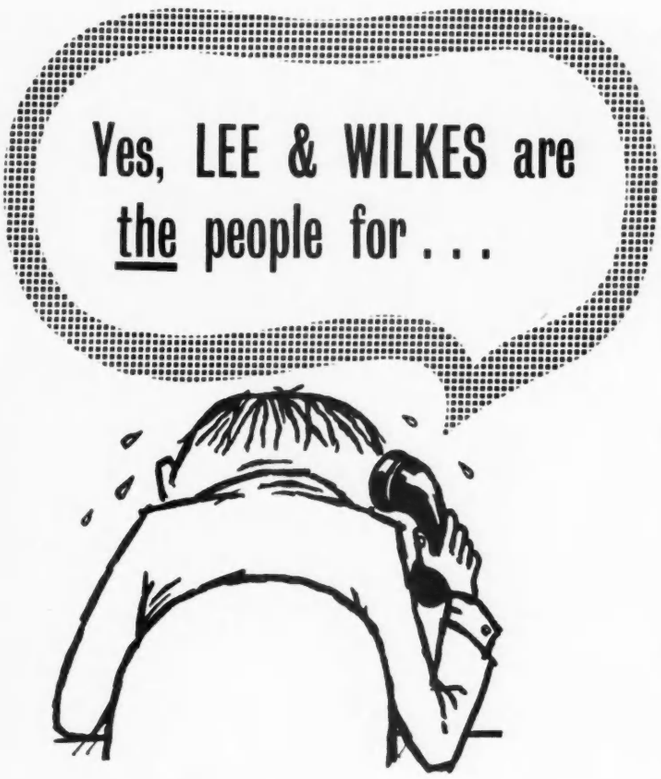

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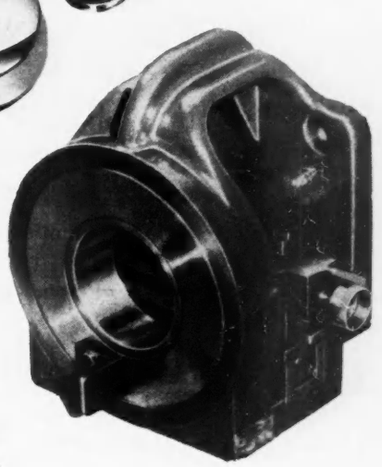
polygon tool box



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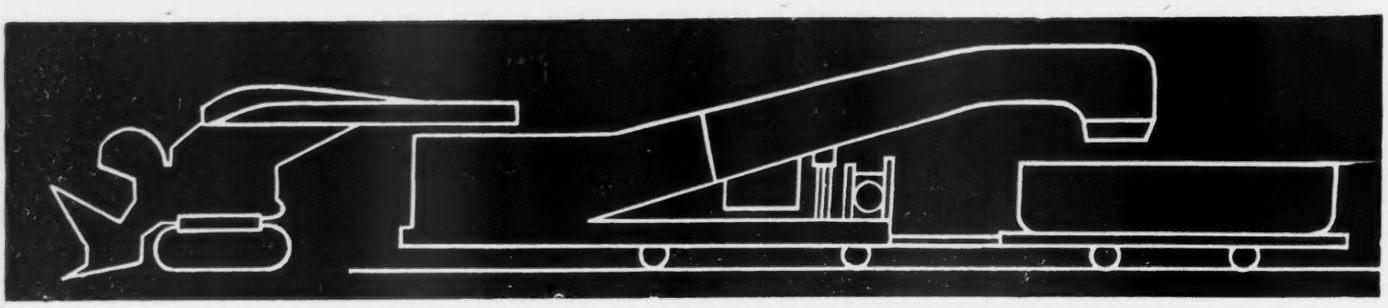

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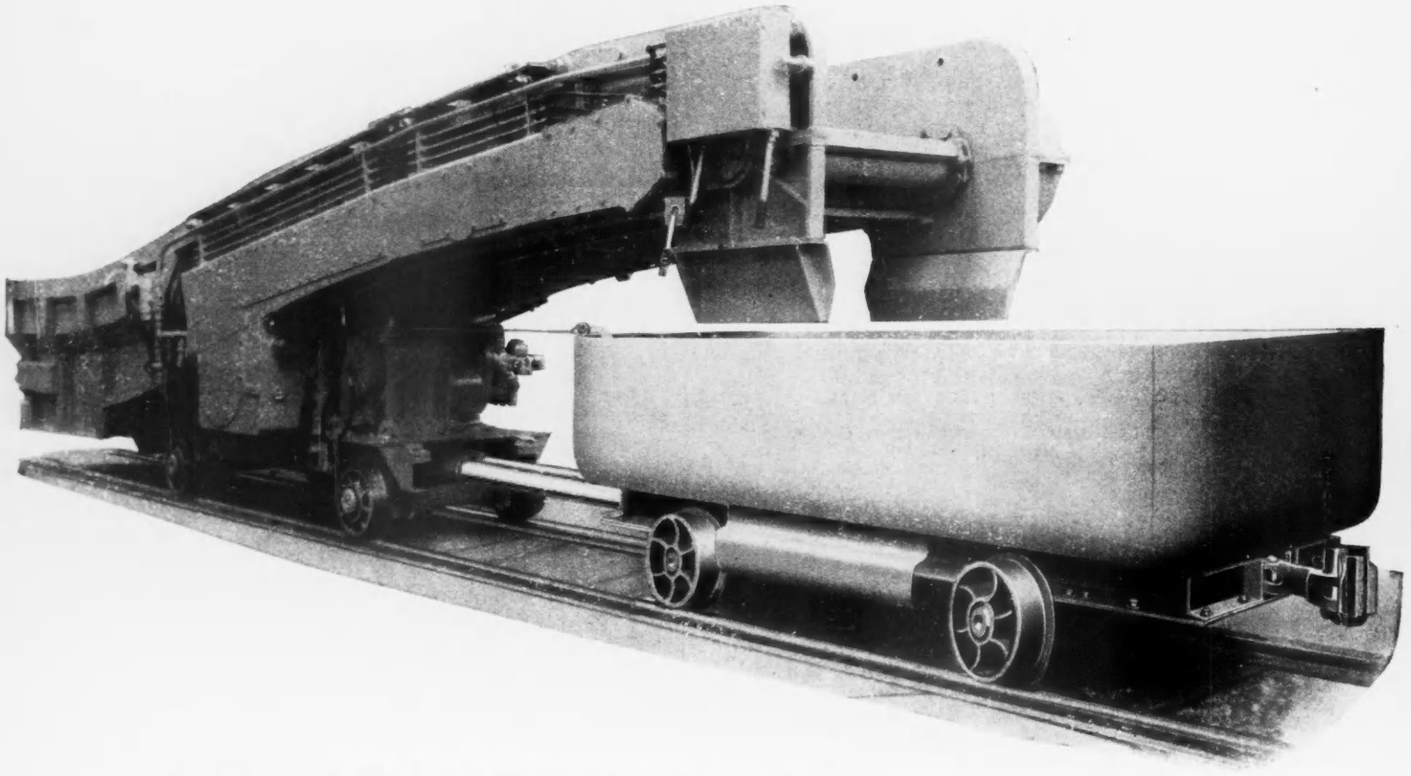
with the aid of
"ALLEN-SOTIM" ACCUMULATOR CAR



With the need for increased drivage in Stone headings, Tunnels, etc., the car-changing time is a vital consideration.

The " ALLEN-SOTIM " ACCUMULATOR CAR has been designed to act as a link which keeps the loader working to capacity and at the same time ensures a flow of car loading with a minimum of man-power.

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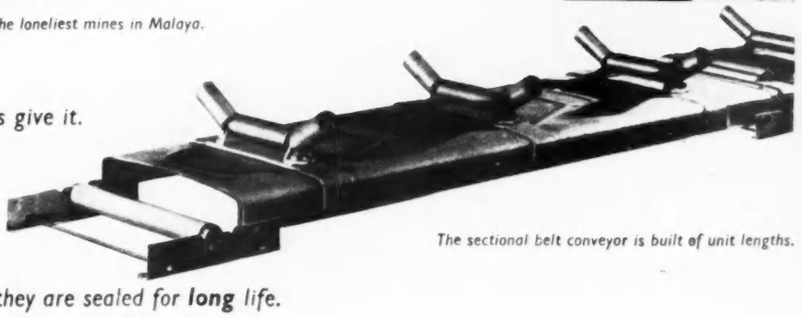
Feeding tin ore to an M&C belt at one of the loneliest mines in Malaya.



The sectional belt conveyor is built of unit lengths.

So remote a site demands reliability. M&C belt conveyors give it. They also give low upkeep cost. The idlers can spin at a touch, and they keep that way, for they resist both dust and deluge. Proof abounds that they are sealed for **long** *life.*

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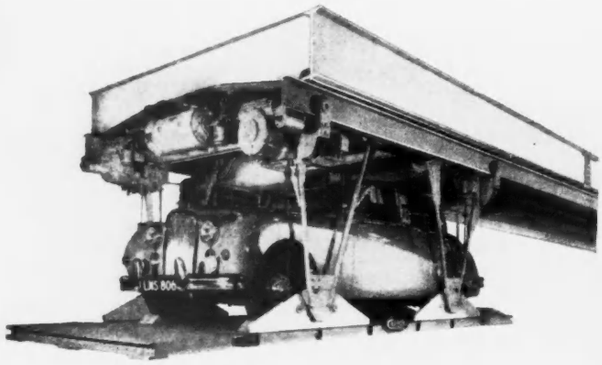

The side loading of cargo using a Carron Transporter is an entirely new approach to the technique of cargo handling. It does not impose limitations on the design of the superstructure and, as well as improving the appearance of the ship, saves valuable passenger accommodation.

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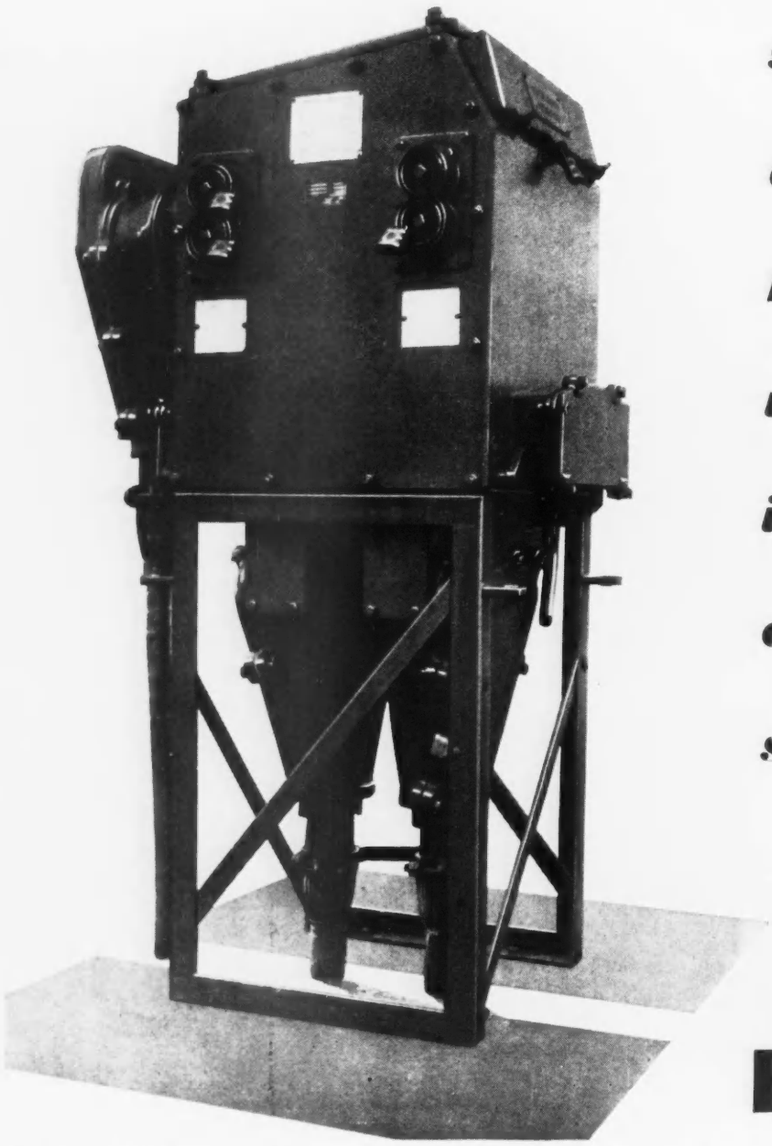

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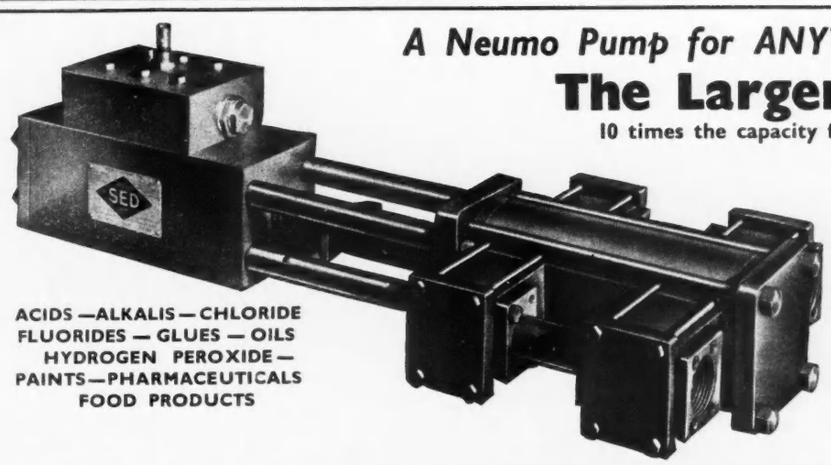
The Larger Mark X

10 times the capacity for 4 times the price



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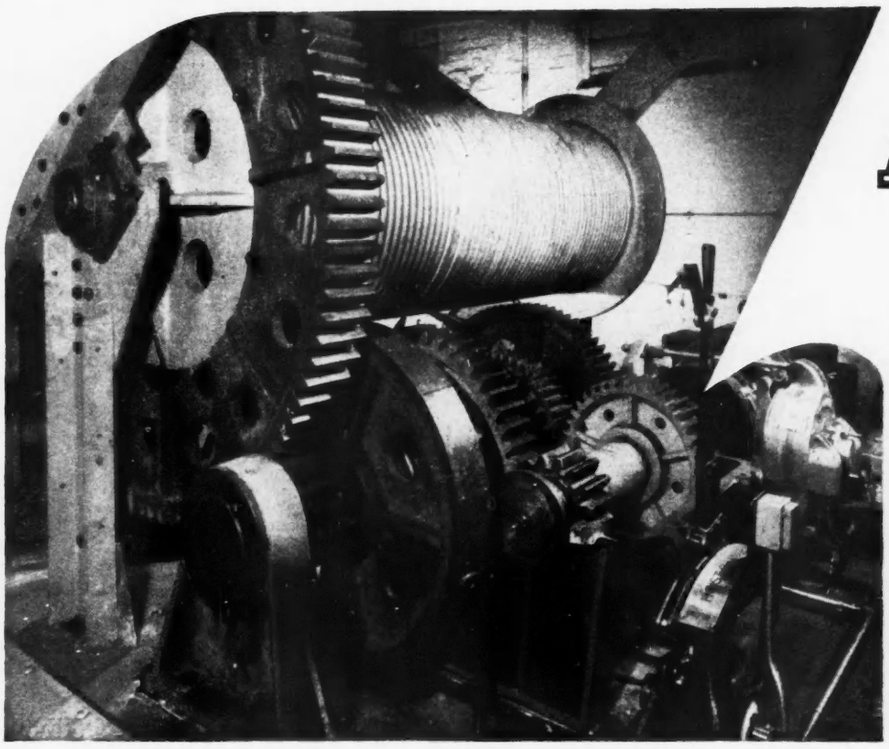

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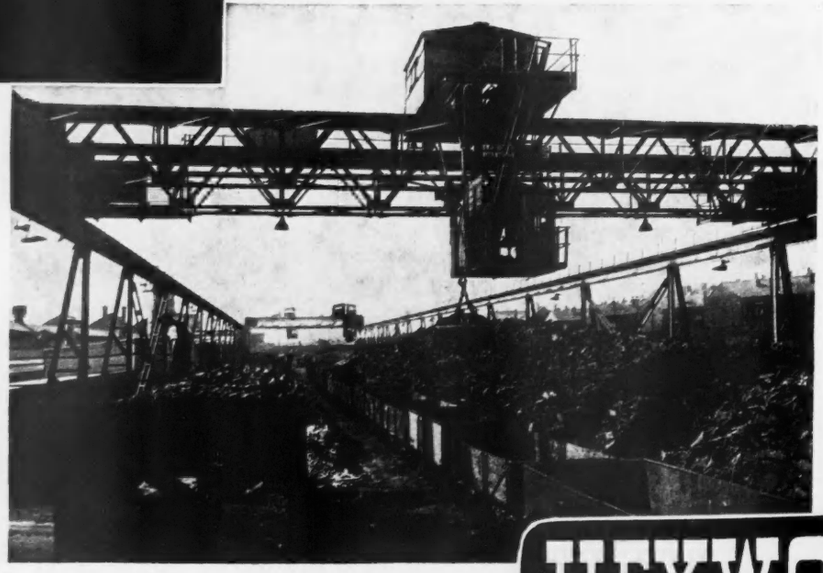

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REDDISH STOCKPORT CHESHIRE

HEYWOOD *Leaders in* CRANES

Telephone : Heaton Moor 2264. Telegrams : "Cranes" Reddish, Stockport. London Office : 44/45, Tower Hill, E.C. 3. Tel : Royal 1461. Grams : "Murimil Fen., London".

SH 79

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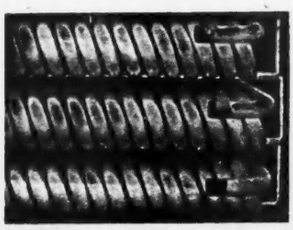
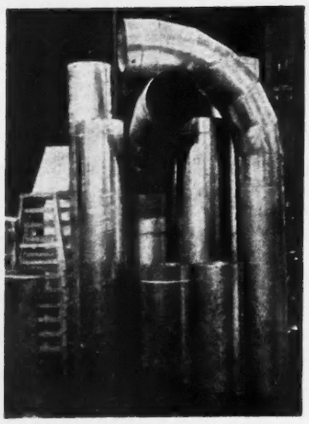


HOT GALVANIZING FIRST MAKES STEEL LAST



For further information write to
the Hot Dip Galvanizers Association
34 Berkeley Square London W.1

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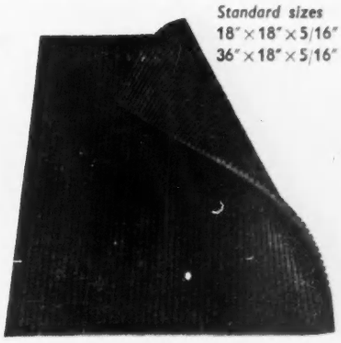
VULCASCOT ANTI-VIBRATION PADS

THE OIL RESISTING
RUBBER MACHINE MOUNTINGS
Tested and proved by years of usage

★ Check vibration, shock and noise
★ Make machine installations easy
★ No fixing bolts required
★ Save maintenance time and cost
★ Combat nervous strain
★ Isolate loads up to 4 tons per sq. ft.

Standard sizes
18" × 18" × 5/16"
36" × 18" × 5/16"



MAKE MACHINES MOBILE

VULCASCOT LEVEL-MOUNTS

incorporate the Anti-Vibration Pads
NO DRILLING OF FLOORS
RAPID LEVELLING WITHOUT SHIMS

For literature
write or phone to the manufacturers :

VULCASCOT (GT. BRITAIN) LIMITED
87-89 ABBEY ROAD, LONDON, N.W.8.
Telephone MAlda Vale 7374/5

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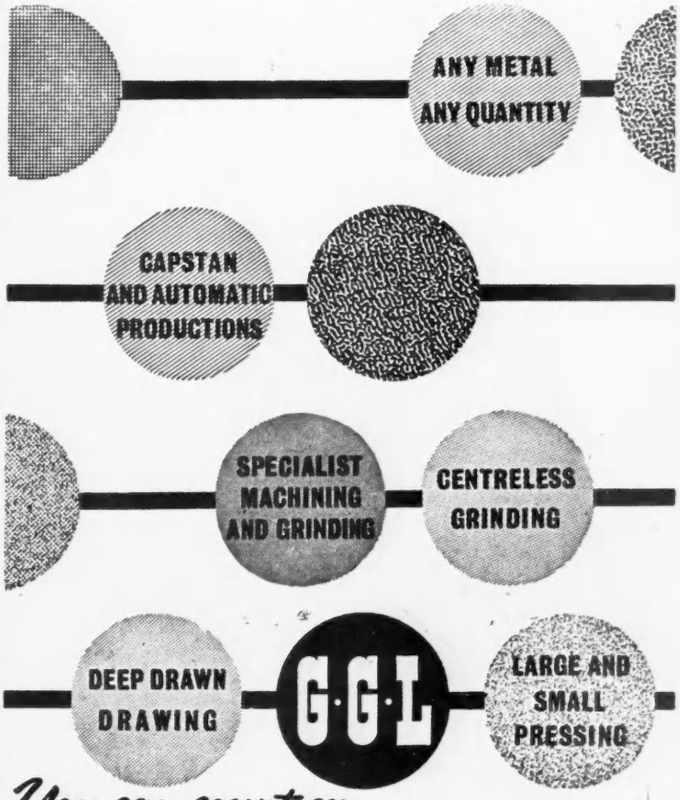

You can count on
GRIFFITHS, GILBART, LLOYD. & CO. LTD.
EMPIRE WORKS, PARK ROAD, BIRMINGHAM 18
Telephone : Northern 6221

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BOLTON'S

H. C. COPPER BUSBARS

Drawn finish up to 3" square or to 10" wide × 1" thick; hard rolled up to 12" × ¼" × 16' 0" long. Extra heavy machined bars to customers' requirements. Tubular and laminated busbars.

PRE-ASSEMBLY WORK ON COPPER BUSBARS

Facilities are available in our Works for bending, sawing, drilling, slotting, and tinning, to customers' requirements.

Approximately 400 tons of H.C. Copper Busbars supplied to The Associated Ethyl Company Limited for their Chlorine Plant. The illustration shows a typical busbar, bent, drilled and slotted to customer's requirements.
Section 8" × ¼".

THOMAS BOLTON & SONS LTD

Head Office: Mersey Copper Works, Widnes, Lancs. Tel: Widnes 2022
London Office and Export Sales Department:
168, Regent Street, W.1. Telephone: REGent 6427.

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LANCASTER BY-PASS

C. A. BLACKWELL

(CONTRACTS) LTD.

Earthmoving Contractors

COGGESHALL ROAD,
EARLS COLNE,
ESSEX

Earls Colne 537

Sub-Contractors to Sir Lindsay Parkinson & Co LTD

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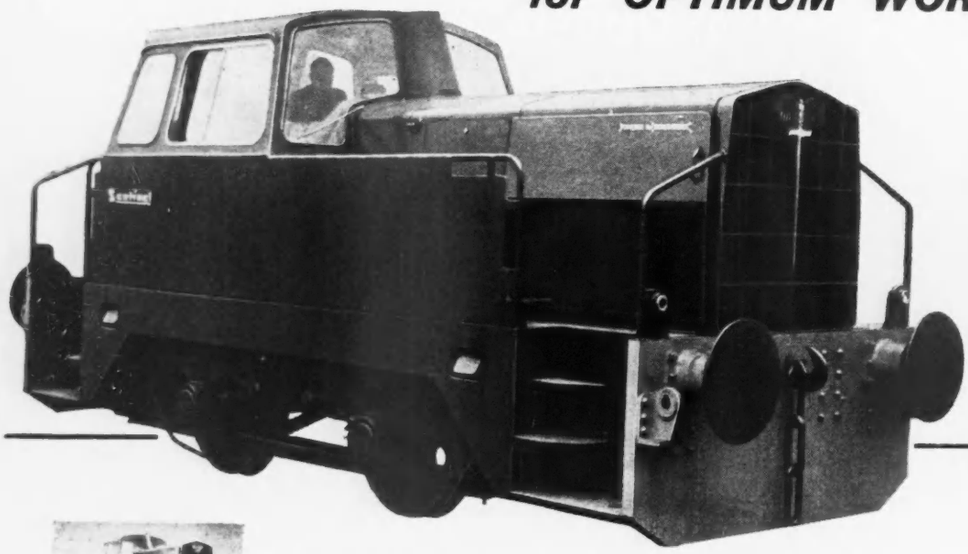
Sentinel industrial locomotives

POWERED BY ROLLS-ROYCE Diesels

for OPTIMUM WORKING EFFICIENCY



These are the locomotives that keep on going with low maintenance costs for the highest performance. Exceptional accessibility, complete all-round vision, bi-directional working and simple controls are features which guarantee the unsurpassed efficiency of the competitively priced Sentinel Rolls-Royce locomotives.

The Rolls-Royce 6-cylinder diesel engine coupled to a torque converter develops 233 b.h.p. (gross) at 1,800 r.p.m.

Send for this informative brochure containing all the essential facts and figures

SENTINEL (SHREWSBURY) LIMITED, SENTINEL WORKS, SHREWSBURY

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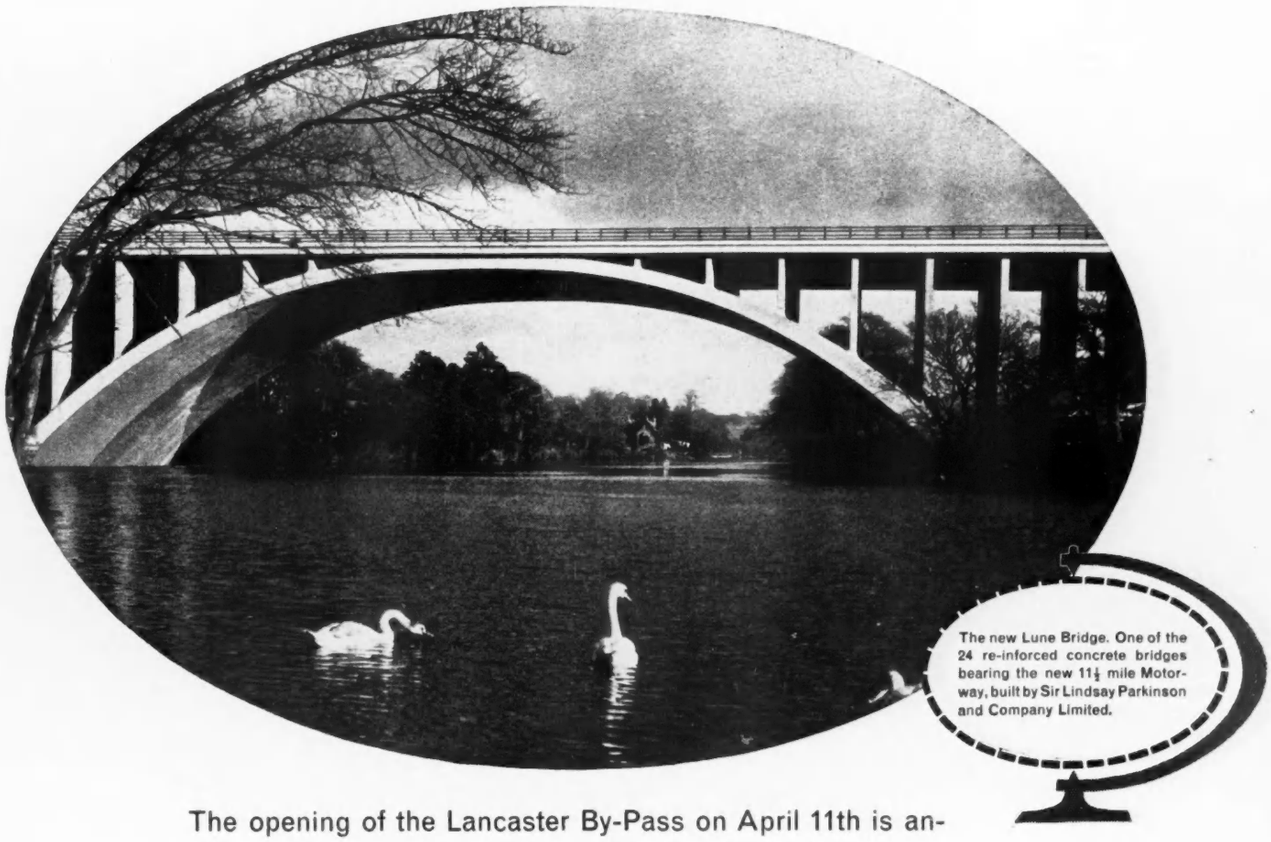
SIR LINDSAY PARKINSON SPAN THE WORLD



The new Lune Bridge. One of the 24 re-inforced concrete bridges bearing the new 11¼ mile Motorway, built by Sir Lindsay Parkinson and Company Limited.

The opening of the Lancaster By-Pass on April 11th is another step forward in providing Britain with the Motorways she needs.
Sir Lindsay Parkinson & Co. Ltd were the main contractors for this three and a half million pound scheme.

THEIR RECENT MAJOR CONTRACTS INCLUDE

NIGERIA: *The first television station in West Africa.* ***CYPRUS:*** *Permanent barracks for the War Department.* ***GHANA:*** *The Tema deep-water harbour (Parkinson-Howard Ltd).* ***BRITISH GUIANA:*** *The Boeraserie Extension Project (drainage and irrigation).* ***AUSTRALIA:*** *A 13-storey building in Sydney containing the Attorney-General's office and barristers' chambers.* ***ENGLAND:*** *The Extension to the Royal Hospital, Chelsea, and a new factory for Vauxhall Motors Ltd, at Luton, as well as various contracts for industrial projects and housing estates throughout the country.*

SIR LINDSAY PARKINSON
AND COMPANY LIMITED

Head office: Sir Lindsay Parkinson & Co. Ltd, 6 Lambeth Road, St George's Circus, London S.E.1

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APN

STRUCTURAL BOLTS

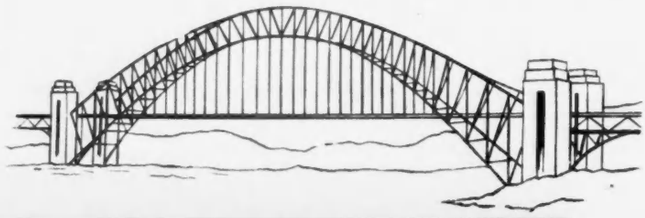
Newallastic

Newall Torshear

"TORSHEAR" Brochure available on application

NEWALLASTIC STRUCTURAL BOLTS can be tightened to their ultimate tensile stress with an adequate margin of safety, thus enabling designers to make the fullest use of bolting when designing steel structures.

NEWALL TORSHEAR BOLTS used with the special Torshear air-tool provide automatically controlled tightening governed by the shearing of the extension on the bolt.



A.P.Newall
AND COMPANY LIMITED
POSSILPARK · GLASGOW N.2.

ALSO AT LONDON AND BIRMINGHAM

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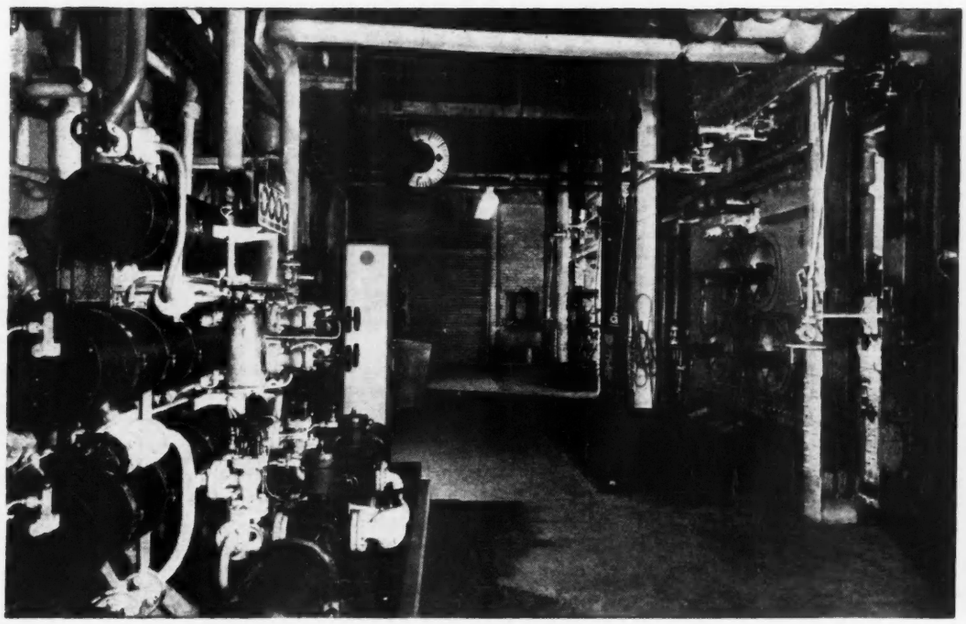

GLAXO LABORATORIES LTD
have installed

Thornycroft Oil Burning Equipment on their Babcock & Wilcox Water Tube Boilers at Greenford. We supplied the whole of the oil firing equipment and the conversion from solid fuel to oil firing was engineered by our technical staff.

Other recent Thornycroft installations include those at Selfridges Ltd., London Airport, Shell-Mex House and several for the Ministry of Works.

For particulars of industrial equipment write for publication S.E.B.99 which includes a questionnaire for completion and return to us.

THORNYCROFT
OIL BURNING EQUIPMENT

FUEL EFFICIENCY & POWER FOR INDUSTRY EXHIBITION
Grand Hall, Olympia, London
April 27th—May 6th
On **STAND 8, ROW G** we shall be showing a duplex PUMPING & HEATING unit for an installation at the Birkenhead Hospital of the Liverpool Hospital Board and colour enlargements of recent Industrial & Marine installations.

JOHN I. THORNYCROFT & CO. LIMITED, WOOLSTON WORKS, SOUTHAMPTON

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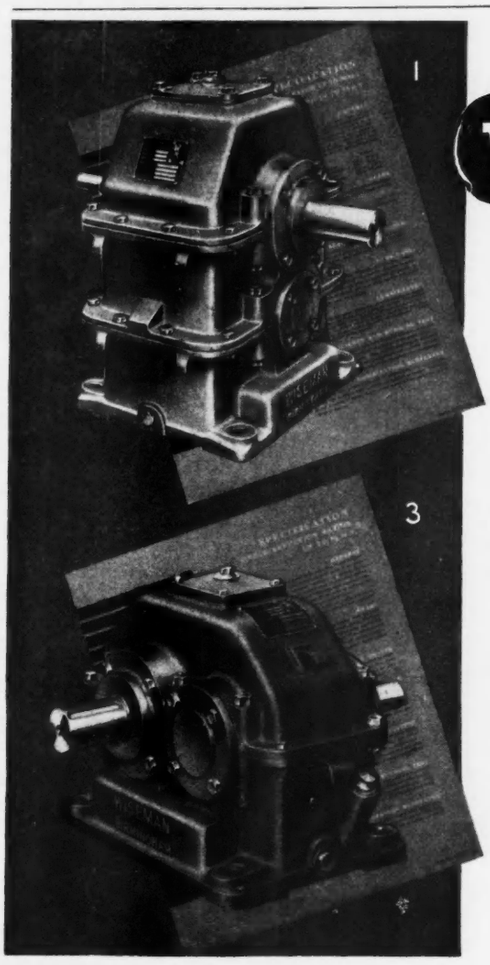


WISEMAN

4 LEAFLETS
on
totally enclosed, spur or helical gear units for industrial drives

(1) LEAFLET GB53
Co-axial type spur or helical gear units. Types DRCO and DRCV. Double reduction ratios up to 50 to 1. Single reduction ratios up to 7½ to 1.

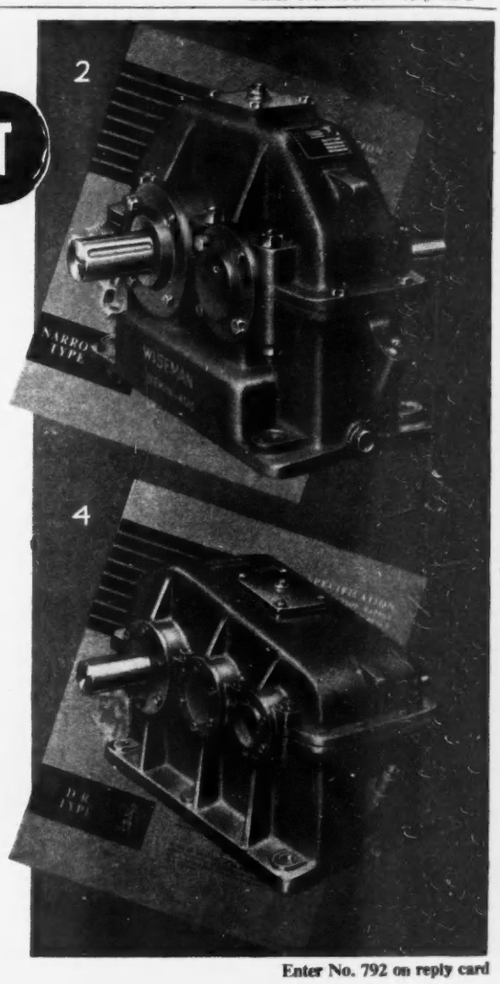
(2) LEAFLET GB51
Single reduction spur or helical gear units. Type SR-N narrow. Ratios up to 5 and 10 to 1.

(3) LEAFLET GB/50/1
Single reduction spur or helical gear units. Type SR-W wide. Ratios up to 5½ to 1.

(4) LEAFLET GB52
Double reduction spur or helical gear units. Type DR horizontal. Ratios up to 60 to 1.

For these leaflets or any further information write to:
ALFRED WISEMAN & CO. LTD.
Glover Street, Birmingham.
London Office: **8 Southampton Row, W.C.1.**

★ See us on STAND KK11
Mechanical Handling Exhibition
Earls Court May 3-13



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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/–. **Inch Rate.** 54/– per single column inch and pro rata. 12 lines to 1 inch.
There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/– per line of approximately 6 words. Minimum 16/–. **Inch Rate.** 48/– per single column inch and pro rata. 12 lines to 1 inch.
There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an Illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/– which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to :—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

BRIGHTON EDUCATION COMMITTEE

PRESTON TECHNICAL INSTITUTE

GRADUATE LECTURERS

Required from September (new posts) :

1. GRADUATE LECTURER in MATHEMATICS, for work mainly with part-time day O.N.C. and City and Guilds Final courses. Teaching experience with H.N.C. courses in Electrical Engineering an advantage.

2. GRADUATE LECTURER in ELECTRICAL ENGINEERING, with experience of H.N.C. work in Electrical Technology and Machines. Work mainly with O.N.C. and City and Guilds Final courses.

Further particulars and application forms, obtainable from the undersigned, to be returned to the Principal, Preston Technical Institute, Coombe Road, Brighton, by 30th April, 1960.

W. G. STONE,
Director of Education.

54, Old Steine,
Brighton. E9508

UNIVERSITY OF MANCHESTER

SENIOR LECTURER AND LECTURER IN ENGINEERING

Applications are invited for the posts of SENIOR LECTURER and LECTURER IN ENGINEERING (Mechanical). Preference will be given to candidates with a major interest in Applied Thermodynamics or Applied Mechanics, especially Theory of Machines. Some experience of Mechanical Design would be an advantage. University regulations permit teaching staff to read for the Degrees of M.Sc. and Ph.D.

The salary scales per annum are as follows ; Senior Lecturer, £1700 to £2050 ; Lecturer, £900 to £1650. Membership of F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience.

Applications should be sent not later than May 7th, 1960, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained. Applications by air-mail letter, in the first instance, will be considered from overseas candidates. E9482

UNIVERSITY OF BRISTOL

LECTURERS

Applications are invited for two posts as LECTURER (one Grade III and one Grade II) in the Department of Mechanical Engineering. The salary scales are now under revision and are likely shortly to be increased, but the range is at present :

Grade III : £700 to £850 per annum.
Grade II : £900 to £1650 per annum.

(according to qualifications and experience) with F.S.S.U. benefits and Family Allowance.

The duties will consist of lecturing, laboratory and tutorial work and the supervision of research projects. There are ample opportunities and facilities for personal research work in new and expanding laboratories.

Applications (including the names of two referees) should be sent not later than 30th April, 1960, to the undersigned from whom further particulars may be obtained.

H. C. BUTTERFIELD,
E9505 Registrar and Secretary.

ESSEX EDUCATION COMMITTEE

MID-ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART, MARKET ROAD, CHELMSFORD

SENIOR LECTURER

Required, September, 1960 : SENIOR LECTURER IN MECHANICAL ENGINEERING, for Strength of Materials, Theory of Machines, Theory of Structures, mainly for H.N.D. and N.H.C. Courses. Degree or equivalent, Corporate Membership and teaching experience expected.

Salary : Senior Lecturer, £1550 by £50 to £1750 per annum.

Details and forms (stamped, addressed foolscap envelope) from the Clerk to the Governors. E9524

PUBLIC APPOINTMENTS

UNIVERSITY OF LIVERPOOL

UNIVERSITY FELLOWSHIPS IN THE FACULTY OF ENGINEERING

Applications are invited for the following awards :

A limited number of UNIVERSITY FELLOWSHIPS IN THE FACULTY OF ENGINEERING, value £450 per annum, tenable for one year in the first instance, but renewable for a second year.

A limited number of Postgraduate Studentships, value £245 per annum, tenable for one year, but renewable for a second or third year.

The holder must pursue a full-time course of training in research within the University.

Applications, which should include particulars of age, academic career and qualifications, together with the names of three referees and quoting Ref. CV/E, and accompanied by published or manuscript work, should be received not later than 7th May, 1960, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. E9397

PRISON COMMISSION

H.M. BORSTAL, FELTHAM, MIDDLESEX

CIVILIAN INSTRUCTIONAL OFFICER, GRADE III (FITTER MACHINIST)

CIVILIAN INSTRUCTIONAL OFFICER, Grade III (FITTER MACHINIST). Post at H.M. Borstal, Feltham, Middlesex, and to act as relief at other establishments as necessary. Candidates must be aged at least 30 on 13th May, 1960.

Qualifications : Full apprenticeship plus at least 5 years' practical experience. Able to instruct in machine shop engineering. City and Guilds Certificate (or equivalent) and some teaching experience desirable.

London salary scale : £825–£950. Prospects of pensionable employment. 44-hour week and holidays with pay. Quarters not provided.

Write, Prison Commission, R.241/254, Horseferry House, Dean Ryle Street, London, S.W.1, for application form.

Closing date : 29th April, 1960. E9494

GHANA

TEMA DEVELOPMENT CORPORATION

ASSISTANT ENGINEER

A vacancy exists in the office of the Chief Engineer to the Corporation for an ASSISTANT ENGINEER.

Qualifications and experience : Candidate should hold a minimum qualification of (a) Engineering Degree plus 2 years' post-graduate experience ; (b) Sections I and II Institution of Civil Engineers ; or (c) Testamur Examination, Institution of Municipal Engineers. Salary in range £1080 to £1580 p.a.

Appointment on contract, initially for two tours each of 15-18 months. Successful candidate will be required to contribute to the Corporation's Provident Fund, at the rate of 7½ per cent of salary, the Corporation's contribution being 17½ per cent.

Apply, stating age, qualifications and experience to The Director of Recruitment, Ghana High Commission (Recruitment Section), 248-250, Tottenham Court Road, London, W.1. E9509

THURROCK URBAN DISTRICT COUNCIL

TWO ASSISTANT ENGINEERS

Thurrock Urban District Council (population 107 100 increasing) (Engineer and Surveyor's Department) require TWO ASSISTANT ENGINEERS. Salary, A.P.T. IV : £1065 to £1220 p.a. Applicants should be Chartered Civil or Municipal Engineers, or have equivalent qualifications, and have extensive civil engineering experience and be capable of designing and supervising construction of major schemes. In particular, experience is desired in sewerage and sewage disposal and or bridges and roads. Housing accommodation may be considered if successful candidates reside more than 20 miles from Thurrock. Appointment pensionable. Applications, stating age, qualifications, and experience, and quoting three referees to the Clerk of the Council, Council Offices, Grays, Essex, by 26th April, 1960. Canvassing disqualifies. Relationship with Members or Senior Officers of the Council must be disclosed. E9510

PUBLIC APPOINTMENTS

WESTERN NIGERIA DEVELOPMENT CORPORATION

ASSISTANT MECHANICAL ENGINEER

The Corporation invites applications from suitably qualified candidates for post of ASSISTANT MECHANICAL ENGINEER in its Engineering Department.

Qualifications : Candidates should possess one of the following qualifications :—

(a) A.M.I.Mech.E. or approved equivalent qualification awarded by an Institution outside Great Britain.
(b) A recognised Diploma or University Degree in Mechanical Engineering with adequate practical experience in operation and maintenance of Plants and Vehicles.

In addition, candidates must have had at least five years of post-graduate employment, two of which must have been in a responsible position, and are expected to have had some experience in the following :—

(a) Workshop Management.
(b) Office and Stores Organisation.
(c) Estimating and Control of Finance.
(d) Control of Transport, Plant and Finance.
(e) Maintenance, inspection, repair and overhaul of all classes of motor transport, earth moving equipment, Contractors' plant, diesel fuel oil injection equipment, air-conditioning and refrigerating plant, and wood-working machine shops.

Duties : The Officer appointed will be posted for duties in one of the Corporation's Maintenance Mechanical Workshops, which may be anywhere in the Western Region of Nigeria.

Salary Scale : £1360 : £1420 : £1470, by £60 to £1590 per annum, plus inducement allowance of £300 per annum for an Overseas officer. Point of entry will depend on qualifications and experience. Prospects for early promotion are excellent.

Terms of Service : The terms of service include partly furnished accommodation at the rate of 8⅓ per cent of the basic salary ; free medical service. (In the case of an expatriate being appointed, an outfit allowance for candidates coming to the tropics for the first time is payable, and a free passage for wife and free passages once each way per tour for children up to 3 in number not over the age of 13 are provided.) Employee is required to contribute 10 per cent of salary to a Provident Fund ; the Corporation contributes an equal amount. Leave at full pay is granted at the rate of 5 days for every completed month of service. Normal length of tour is 18/24 months.

Applications, stating age, qualifications and experience, with the names of three referees, should be forwarded to reach the Official Secretary (Recruitment Branch), Office of the Commissioner, Western Region of Nigeria, 178/202, Gt. Portland Street, London, W.1, not later than Saturday, 23rd April, 1960.

E9479

HER MAJESTY'S OVERSEAS CIVIL SERVICE

PUBLIC WORKS DEPARTMENT, HONG KONG

PLANNING OFFICER

To prepare plans and conditions for development schemes of all types. General Town Planning duties and consideration of private and public building proposals.

Pensionable appointment. Age limit 45. Salary scale £1500 to £2865 with point of entry between £1650 and £2325 according to experience. Rented quarters. Free passages. Candidates must be A.M.T.P.I. and have a minimum of one year's post qualification experience, preferably with A.M.I.C.E. or A.M.I.Mun.E., or secondly A.R.I.B.A. or A.R.I.C.S.

Write Director of Recruitment, Colonial Office, London, S.W.1, giving full names, age, qualifications and experience, quoting BCD 112/51/031/D4. E9517

PUBLIC APPOINTMENTS

SOUTH OF SCOTLAND ELECTRICITY BOARD

HEATING AND VENTILATING ENGINEER

Applications are invited for a superannuable appointment as a HEATING AND VENTILATING ENGINEER in the Development Section of the Chief Commercial Officer's Department at Board Headquarters.

Duties will comprise the design of space heating and ventilation schemes, including hot water, central heating using electrode boilers and similar equipment.

Candidates should have a sound technical training in heating and ventilation. Experience in the preparation of estimates, specifications and drawings for central heating plants is required. Qualifications leading to membership of the Institution of Heating and Ventilating Engineers are desirable.

Salary, N.J.B., Class AX/EX, Grade 5—£1090 to £1355 per annum.

Apply, quoting reference number C2/60, on the standard form available from the Secretary, South of Scotland Electricity Board, Inverlair Avenue, Glasgow, S.4, not later than 29th April, 1960 E9516

BOARD OF GOVERNORS, HAMMERSMITH AND ST. MARK'S HOSPITALS, DU CANE ROAD, LONDON, W.12

APPOINTMENT OF CHIEF ENGINEER

Applications invited for the appointment of CHIEF ENGINEER of the Hammersmith and St. Mark's Hospitals, a post-graduate general teaching group of hospitals. Candidates must hold corporate membership of the Institution of Mechanical Engineers, or an equivalent qualification in mechanical engineering. A recognised qualification in electrical engineering would be an advantage. Salary scale £1375 by £45 (5) to £1600 p.a., plus £50 London Allowance. A gratuity of up to 10 per cent of salary will also be payable for hours worked in excess of normal 38-hour week. An additional payment will be made for supervisory duties for other authorities on the Hammersmith Hospital site. The successful candidate will be required to take up his duties on the 1st November, 1960. Full details of duties and conditions of service may be obtained from the Secretary of the Board. E9513

CITY OF BRADFORD

SENIOR ENGINEERING ASSISTANT

Applications are invited for the superannuable appointment of a SENIOR ENGINEERING ASSISTANT, Post 18, in the City Engineer and Surveyor's Department on A.P.T. IV (£1065–£1220).

Candidates should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had special experience in design of reinforced concrete and steel structure for multi-storey flat construction.

No housing accommodation can be provided by the Corporation.

Applications on forms to be obtained from the City Engineer and Surveyor, Town Hall, Bradford, 1, together with three testimonials, must be received by the undersigned by 2nd May, 1960.

HENRY PATTEN,
E9522 Town Clerk.

RUNWELL HOSPITAL, NEAR WICKFORD, ESSEX

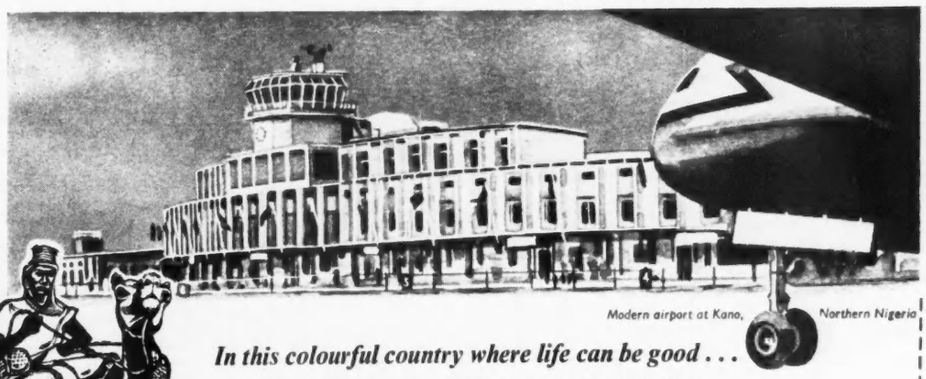
SENIOR ENGINEER

SENIOR ENGINEER required. Must hold Ministry of Transport and Civil Aviation First Class Certificate of Competency in Marine Engineering, Certificate of Service as First Class Engineer, City and Guilds Full Technological Certificate in Plant Engineering (First Class), or approved equivalent qualification.

Health Service Whitley Council conditions : pensionable. Present salary scale £730–£870. The Officer is required to occupy the house provided (present rent £1 13s. 5d. a week, subject to variation).

Applications, quoting two referees, to the Secretary, not later than 30th April, 1960. E9498

PUBLIC APPOINTMENTS



Modern airport at Kano, Northern Nigeria

In this colourful country where life can be good . . .

REWARDING POSTS WAIT TO

WELCOME EXECUTIVE ENGINEERS

Northern Nigeria's attractions are not confined to its dramatic contrasts and kaleidoscopic colours. For today's qualified engineers they extend to the excellent conditions of an appointment in a country determined on progress in every direction. There are several vacancies just now on executive level.

QUALIFICATIONS ARE AS FOLLOWS:
University Degree or Diploma in Civil Engineering recognized by the British Institution of Civil Engineers as exempting from the Parts I and II of the Institution Examination, and at least two years' subsequent practical experience in Civil Engineering; or . . .

Any other equivalent professional training or qualification recognized by the Institution.

A desirable (though not essential) qualification is corporate membership of the Institution of Civil Engineers.

Duties are these: (1) (a) Reconnaissance, survey and construction of roads.
(b) Investigations for bridges and culverts; design and supervision of their construction.
(c) Supervision of road maintenance and improvements, including tarring.
(2) Duties *may* necessitate living away from towns for considerable periods.

Candidates will not be expected to possess advanced specialized knowledge in any one subject and will be encouraged to develop breadth of experience, due weight being given to their wishes in a country where responsibility comes at an early age. Works are carried out by contract, petty contract, and by direct labour.

HIGH SALARY, LOW TAX

Initial salary is £1,440 p.a. gross and ascends in accordance with candidates' experience. Salary is subject to Northern Nigerian income tax rate which is remarkably low, commencing at 4½d. in the £ for the first £200 of income.

GOOD ALLOWANCES, GRATUITY

There are generous allowances, and living quarters are provided at low cost. A further consideration is a gratuity at end of term of service.

PASSAGE PAID—ON LEAVE, TOO

First-class paid passages for accepted candidates and wives also apply to homecoming on leave at end of only 18 months' service.

These facilities are renewed if a further term of service is arranged.

Civil Engineers like you are already there

NORTHERN NIGERIA

These attractive openings may be applied for in writing in the first instance to the Recruitment Secretary, Northern Region, Room E,

NIGERIA HOUSE · NORTHUMBERLAND AVENUE · LONDON · W.C.2

E9348

BOROUGH OF SWINDON

WATER DEPARTMENT

SENIOR ENGINEERING ASSISTANT

SENIOR ENGINEERING ASSISTANT required for work on the design and construction of major capital works and on ground water surveys. Works in progress and projected in this rapidly expanding Water Undertaking amount to £600,000, involving boreholes, pumping plant, buildings, trunk mains, &c.

Salary in accordance with either A.P.T. Special Grade (£785-£1070) or A.P.T. Grade IV (£1065-£1220) depending on qualifications and experience.

Housing Accommodation and assistance with removal expenses offered to married candidates. Five-day week in operation.

Application forms, with further details, may be obtained from the Town Clerk, Civic Offices, Swindon, and should be returned by 25th April, 1960. E9400

TENDERS

GOVERNMENT OF THE GAMBIA

PUBLIC WORKS DEPARTMENT

BARRA FERRY TERMINAL

TENDERS are invited from experienced Contractors for the CONSTRUCTION of a FERRY TERMINAL at Barra, on the North bank of the estuary of the Gambia River.

The works consist of a piled access jetty approximately 10`0 feet long in reinforced concrete, a solid berthing head, incorporating a vehicle landing ramp, and shore ancillaries.

Copies of the Tender documents and drawings, to be issued as from 25th April, 1960, may be obtained from the Consulting Engineers, Messrs. G. Maunsell and Partners, 66, Haymarket, Westminster, London, S.W.1. Applications must be accompanied by a deposit of £10 which will be refunded on receipt of a bona fide Tender and the return of all Tender documents and drawings.

Tenders should be delivered simultaneously to the Major Tender Board, Bathurst, and a duplicate copy to the Consulting Engineers, Messrs. G. Maunsell and Partners, 66, Haymarket, Westminster, London, S.W.1, not later than 6th June, 1960.

The lowest or any Tender will not necessarily be accepted.

E9502

TENDERS

INDIA SUPPLY MISSION

The Office of the India Supply Mission, 2536, Massachusetts Avenue, N.W., Washington, 8, D.C., United States of America, invites TENDERS for the following.

(a) TENDER ENQUIRY No. SE.157.
For the SUPPLY of ONE number SELF-PROPELLED, Diesel or Diesel-Electric-operated 5 tons MOBILE CRANE, Slewing Type.

(b) TENDER ENQUIRY No. SE.161.
For the SUPPLY of 33kV. UNDERGROUND CABLES and 11kV. FLEXIBLE CABLE COUPLERS required by Neyveli Lignite Corporation (Private), Ltd., Madras, India.

Specifications, &c., relative to the above specifications, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and 3 pence per Tender enquiry, and is not refundable.

Tenders are to be returned direct to India Supply Mission, 2536, Massachusetts Avenue, N.W., Washington, 8, D.C., United States of America, so as to reach them by : (a) 31st May, 1960 ; (b) 2nd June, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, India Store Department, Bromyard Avenue, Acton, W.3, under the following references : (a) S.4254/59/NSC/ENG.2 ; (b) S.4261/59/NSC/ENG.2. E9501

INDIA STORE DEPARTMENT

The Office of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) 6-SPINDLE AUTOMATIC. Nominal O.D. of chuck 6in. Max. length turned 7in. Spindle speeds 108–1154 r.p.m.

(b) DEEP HOLE BORING MACHINE for Gun Barrel. Single spindle for boring and drilling operation up to 108mm diameter by 3658mm. long. Similar to SIG type B50-100/4.

(c) COPYING LATHES, similar to George Fischer. Model KDM/11/100.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender enquiry, and is not refundable. Tenders are to be returned to the above address by Thursday, 26th May, 1960. Specimen copy of the above enquiries can be seen at Engineering Branch, I.S.D., under the following references :

(a) 2045/59/SSB/ENG.3.
(b) 2046/59/SSB/ENG.3.
(c) 2048/59/SSB/ENG.3. E9481

EDUCATIONAL

COLLEGE OF AERONAUTICS

A Course of Lectures on

PROBLEMS IN HYPERSONIC AERODYNAMICS

will be given at the College from Monday, 2nd May, to Friday, 13th May, 1960.

The course is intended for aerodynamicists, physicists and research workers who require a working knowledge of hypersonic aerodynamics. A knowledge of subsonic and supersonic aerodynamics and of mathematics up to degree level is desirable.

FEES for the course are :
Tuition Fee 30 guineas.
Residence Charge (including full board), 10 guineas.

Forms of enrolment and copies of the syllabus may be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E9244

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, ST. JOHN STREET, LONDON, E.C.1.

Two Lectures on "COMPACT HIGH PERFORMANCE HEAT TRANSFER SURFACES" will be given at 7 p.m. on 27th April and 4th May, 1960, by Professor W. Kays, M.S., Ph.D., Professor of Mechanical Engineering, Stanford University, U.S.A.

The lectures will deal with (a) the heat transfer and friction power relationships for heat transfer surfaces with special reference to high performance extended surfaces, and (b) recent developments in heat surfaces.

Fee for the Course, 10s.

Enrolment can be effected by personal attendance at the College or by application for an enrolment card. E9514

UNIVERSITY OF LONDON

A COURSE OF THREE LECTURES on : (i) "The Role of the Engineering Sciences in Engineering Education" ; (ii) "Metallurgy, Materials Sciences and Engineering" ; (iii) "The Anatomy of Extractive Metallurgy," will be delivered by Professor R. Schuhmann (Purdue University) at Imperial College of Science and Technology, Royal School of Mines (Metallurgy Lecture Theatre), Prince Consort Road, S.W.7, as follows : Lecture (i) at 11.15 a.m. on 26th April ; Lecture (ii) at 3.30 p.m. on 26th April ; Lecture (iii) at 3.30 p.m. on 27th April.

ADMISSION FREE, WITHOUT TICKET.

JAMES HENDERSON,
Academic Registrar.

E9484

EDUCATIONAL

ADMIRALTY

ROYAL CORPS OF NAVAL CONSTRUCTORS

SCHOOLS ENTRY

A competition for entry into the Royal Corps of Naval Constructors will be held in July, 1960.

2. Accepted candidates will be established as probationers in the Royal Corps of Naval Constructors and will undergo a two-year course of training at the R.N. Engineering College, Manadon, and in H.M. Dockyard, Devonport, followed by a three-year course at the R.N. College, Greenwich.

3. Candidates must be aged between 17 years 6 months and 19 years 6 months, inclusive at 1st September, 1960.

4. Candidates with the General Certificate of Education will be required to have passed at Advanced Level in at least Pure Mathematics, Applied Mathematics, and Physics taken on the same occasion, and at least Ordinary Level passes in English and a language other than English.

5. Candidates with the Scottish Leaving Certificate will be required to have Higher grade passes in Science (to include Physics), Mathematics, at least two additional mathematical subjects (one of which must be Dynamics), and at least lower grade passes in English and a language other than English. Passes to be gained at not more than two sittings of the Scottish Leaving Certificate examination.

6. Candidates with the Northern Ireland Grammar School Senior Certificate will be required to have passes at Advanced Level in Mathematics (General Course, Pure Mathematics, Applied Mathematics) and Physics—taken on the same occasion ; and at least Ordinary Level passes in English and a language other than English.

7. Applications will be considered from candidates who sit these examinations in 1960.

8. The work of the R.C.N.C. covers all aspects of design, construction and repair to H.M. Ships. Members undertake to serve wherever required at Admiralty headquarters, Outports in the United Kingdom and at Royal Dockyards at home and abroad.

9. The starting pay of a probationer at age 18 will be £545. A deduction of £75 is made when living in at the R.N. Engineering College, Manadon, or at the R.N. College, Greenwich. The successful probationer can expect an appointment as Assistant Constructor at age 23 or 24 with a starting salary of not less than £910 and £940 respectively. Promotion to Constructor normally takes place at about age 30 with a salary which may be expected to be not less than £1515, rising in nine years to not less than £2255. Promotion to higher ranks is by selection.

10. Full particulars may be obtained from the Secretary of the Admiralty, Civil Establishments Branch II(88), Empire Hotel, Bath, quoting reference number 6015, to whom final application must be submitted by 16th May, 1960. E8783

Classified Advts. continued on page 82

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS

and

EXHIBITION BURSARY

Applications for the above Bursary are invited from Graduate Engineers or those holding equivalent professional qualification in civil or municipal engineering, and with professional experience.

The Bursary, value £750 and tenable for one year, has been established at the College by the Council of the Public Works and Municipal Services Congress and Exhibition, to enable suitable persons to undertake post-graduate studies or research in Public Health Engineering or Highway Engineering.

Application forms for return by 1st June, 1960, and further details may be obtained from the Professor of Civil Engineering. E9515 F

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN EXPANDING COMPANY operating on a continuous process basis has vacancies for two well-qualified MECHANICAL ENGINEERS in London and South Wales. Applicants should have sound experience in heavy engineering in addition to their technical qualifications, should have attained a good level of general education. The age limit is 32, and an attractive commencing salary is being offered. Write, stating brief details.—BOX No. E9487, "The Engineer." A

AN INTERNATIONAL FOOTWEAR MANUFACTURER and Distributor require the services of an INDUSTRIAL ENGINEER. Applicants should be capable of preparing drawing board layouts of new factories and extensions to existing factories based on latest methods of material handling and work flow. The successful applicant would be expected to have a basic knowledge of electric power lighting distribution and installations; a basic knowledge of methods study and have a plant engineering background. Some knowledge of the French language would be advantageous. Location will be in modern offices in Oxford Street, W.1, with the opportunity of occasional visits abroad as work requires. Good salary with life cover and pension scheme will be offered to the right man.—Write in first instance to the Personnel Manager, 151, Oxford Street, London, W.1. E9507 A

ADHESIVE TAPES, LTD., manufacturers of Sellotape Brand Pressure Sensitive Products require an additional ENGINEER of B.Sc. or H.N.C. qualifications with the right personality to make use of a wide training in their operations. Maximum age 30 years. The position would suit an Engineer who wishes to use a sound technical background as a basis for a career in industry which will call for versatility, self-reliance and the ability to get things done. Superannuation Scheme. Salary will be assessed on age and experience.—Apply, giving full particulars, to Personnel Manager, Adhesive Tapes, Ltd., Boreham Wood, Herts. E9518 A

BOILER ENGINEERS for commissioning and service work on latest type marine and land installations. Travelling involved. Required qualification is Ministry of Transport certificate or equivalent Naval ranking. Age range 25–40 years. Good conditions and prospects.—Apply in writing to Staff Manager (T. & S.), Foster Wheeler Limited, 3, Ixworth Place, S.W.3. E9402 A

DESIGN ENGINEERS

required for work on the design of large modern Water-tube Boiler Plant, involving problems in combustion engineering, heat transfer and fluid flow. Experience in one or more of these fields is a necessary qualification, and an Engineering Degree would be an advantage but is not essential.

Full particulars, stating age, qualifications and past experience, should be sent to:

Chief Design Engineer,
John Brown Land Boilers, Ltd.,
Whitecrook Works,
Clydebank.

E2804 A

CHIEF CHEMIST required, to be in charge of building materials testing and research laboratories in the outskirts of London. The position offers good salary and participation in pension scheme, housing could probably be arranged. Possibilities of further advancement to Technical Director. Own staff informed. Please send applications outlining previous experience and job histories, stating salary required, which will be treated confidentially.—BOX No. E2802, "The Engineer." A

CONSULTING ENGINEERS in Westminster require ASSISTANT ELECTRICAL ENGINEER, age about 25 to 30, with good training, first-class education and degree or Graduateship of I.E.E.—BOX No. E9490, "The Engineer." A

CONSULTING ENGINEERS require R.C. DETAILERS: minimum three years' experience. Permanent position. Pension scheme, luncheon vouchers.—Send details of experience and salary required to P. R. Bullen and Partners, Dacre House, Dean Farrar Street, Westminster, S.W.1. E9364 A

DEVELOPMENT ENGINEER

required, to work on the design and introduction of a wide variety of production plant and special-purpose machines. Candidates should be qualified Mechanical Engineers, with experience of and interest in design and production engineering problems.

First-class conditions of service, including pension and life insurance scheme.

Please apply, giving age and free details of qualifications and experience, to:

Personnel Manager,
Universal Grinding Wheel Co., Ltd.,
Stafford.

E9521 A

DRAUGHTSMAN required, age 21–25, for original design work in a specialist department incorporating techniques for a wide field of engineering. H.N.C. essential, a knowledge of design of crane, hoist, haulage or similar equipment and workshop experience would be an advantage. Five-day week, voluntary pension scheme, luncheon vouchers. Telephone Mincing Lane 7901 or preferably write to Manager, Cableway Division, British Ropeway Engineering Co., Ltd., Plantation House, Mincing Lane, London, E.C.4. E9523 A

DRAUGHTSMAN experienced in the Design and Detailing of Structural Steelwork required by progressive firm in the Southampton area.—Write, giving full particulars of experience and salary required to BOX No. E2792, "The Engineer." A

DRAUGHTSMAN, widely experienced in design of special and standard steel shuttering and allied builders' equipment. Concrete mould experience an advantage. Holiday arrangements honoured. Write, giving full details of experience and qualifications.—BOX No. E2803, "The Engineer." A

DRAUGHTSMEN required for senior positions, capable of handling all types of refractory engineering work. Must have initiative and be prepared to accept responsibility. Good salaries and prospects.—Please apply Design Engineer, Pilbrico Company, Limited, Westmorland Road, London, N.W.9. E2794 A

DRAUGHTSMEN.—Four required by Tyneside Power Station Contractors, able to work with minimum supervision and having experience in either (a) Electrical Diagrams, Cable Layouts or Signalling. (b) Plant Layouts, Steam and Feed Pipework, &c., or (c) Structural Steel and/or Reinforced Concrete. Write fully in first instance to Chief Draughtsman.—BOX No. E2998, "The Engineer." A

ELECTRICAL ENGINEER

IND COOPE, LIMITED, National Brewers, require an Electrical Engineer for employment in Burton-on-Trent. Applicants, who should be aged 30 to 40 years, must possess H.N.C. or equivalent and be Graduates of I.E.E., having served an apprenticeship with an Electrical Contractor or Manufacturer. Drawing-Office and installation experience desirable, including H.V. and M.V. Distribution Power and Lighting; also preparation of drawings, specifications and tenders. Good opportunity for conscientious worker. Salary dependent on experience and qualifications. The Company operates a Pension Scheme with substantial widows benefits, in the event of death before or after retirement.

Five-day week. Staff Restaurant.

Applications, in writing please, to the Group Personnel Manager, Burton-on-Trent, quoting "Electrical Engineer" in top right-hand corner of letter.

E9511 A

ENGINEER, with H.N.C. or equivalent, and preferably with basic electrical knowledge, to undertake interesting experimental work on Mechanical and Heat Transfer Tests in Research and Development Department.—Reply, stating age, qualifications and salary required to Personnel Manager, The Superheater Co., Ltd., Ashburton Road, Trafford Park, Manchester, 17. E9216 A

ENGINEER required for Development work on Gas Turbine Fuel Systems and Motor Vehicle Turbochargers. Candidates with a Degree and suitable previous experience would be preferred.—Enquiries should be addressed to the Personnel Manager, Simms Motor Units, Ltd., Oak Lane, East Finchley, London, N.2. E9525 A

EXPERIENCED DIESEL ENGINEER required to assist Works Manager, and be trained to supersede him after retirement in near future. Works in S.W. London specialising in the rebuilding of Diesel-powered equipment and Field Service. Knowledge of estimating and costing an advantage. Commencing salary £832 p.a., and superannuation. Good opening and permanency for suitable applicant. Write in confidence, details of qualifications and experience.—BOX No. E9476, "The Engineer." A

INSTRUMENT ENGINEERS.—Simon-Carves, Limited, require Instrument Engineers for employment in U.K. and overseas. Experience of instrumentation of chemical/refinery installations desirable. Men with works training and holding O.N.C. or H.N.C. are preferred. Please forward full details of age, experience and qualifications and quoting Ref. SC.36, to Contract Labour Department, Simon-Carves, Limited, Stockport. E9499 A

FACTORY MANAGER

for Joseph Gartshore and Sons, Ltd., of Perth (one of the Adam Lythgoe Group of Companies). Experience in the manufacture of granulated fertilisers desirable, but not essential, provided applicant possesses good all-round knowledge of mechanical or chemical engineering plant, allied with the ability to organise and control staff. Age limit 45. Scotsman preferred. The factory manager will be responsible to the managing director, and will be in complete charge of the factory, which produces 10,000 tons per annum of granulated fertilisers. Commencing salary according to experience and qualifications, but not less than £1200 p.a.

Please write briefly in the first instance to: JOSEPH GARTSHORE AND SONS LIMITED, of Wigshaw Grange, Culcheth, Warrington, Lancashire.

E9489 A

JUNIOR MECHANICAL DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations. A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Replies giving details of age, qualifications, and experience, and quoting ref. LCL/TE1/19, should be addressed to: Drawing Office Superintendent, LAPORTE CHEMICALS, LIMITED, Oyez House, Fetter Lane, London, E.C.4. E9512 A

LANCASHIRE TAR DISTILLERS require a DRAUGHTSMAN for their Engineering Department.

Applicants should be at least 23 years of age, with experience in chemical plant, pipework, &c., and should preferably be of H.N.C. standard.

Superannuation scheme, canteen.

Applications, in confidence, giving age, qualifications and experience to Chief Engineer, Lancashire Tar Distillers Ltd., Liverpool Road, Cadishead, Nr. Manchester.

E9475 A

MECHANICAL ENGINEER. A young man with good drawing-office experience required for Factory layout and development work by Biscuit Manufacturing Company. He will be required to work at the Engineering Headquarters at Ashby-de-la-Zouch, Leicestershire. Applicants should be of or approaching H.N.C. standard.—Apply in confidence, with full particulars, to the Chief Personnel Officer, Meredith and Drew, Ltd., "Murray House," 43/46, Barbican, E.C.1. E2801 A

NUCLEAR POWER PLANT OPERATION

SHIFT MANAGERS are required by the United Kingdom Atomic Energy Authority, Production Group, at Windscale and Calder Works, Sellafield, Seascale, Cumberland.

Applications are invited from Engineers and Physicists to fill vacancies on the Advanced Gas Cooled Reactor project and at the Calder Hall Nuclear Power Station, to be responsible, on shift, for the safe and efficient operation of their station, including nuclear reactors, steam and electrical generating plant and associated experimental facilities.

Engineers must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or equivalent. Physicists should possess a good Honours Degree. Candidates should have had experience of plant operation, i.e. shift operation in a power station or work on a process plant or large-scale research facility. A course of training at a Reactor School and at an operating Nuclear Power Station will be provided.

Salary within the scale £1370–£1825 per annum, according to qualifications and experience, with additional payments for regular shift work.

Contributory superannuation. Staff housing scheme.

Send postcard for application form, quoting reference P/W.23/H, to Recruitment Officer, U.K.A.E.A., Production Group, Windscale and Calder Works, Sellafield, Seascale, Cumberland.

Closing Date: 25th April, 1960. E9483 A

SENIOR ELECTRICAL DRAUGHTSMAN

required for interesting work on large chemical plant installations. Applicants should have some works experience in heavy industry and technical ability to deal with a large variety of problems. Duties include the preparation of power and lighting schemes. The position is permanent and an attractive salary will be offered to the selected applicant. Modern offices situated in the London, E.C.4, area. Five-day week and superannuation scheme.—Applications will be treated in the strictest confidence.—Replies, giving details of age, qualifications and experience and quoting ref. LCL/TE1/30 should be addressed to:

The Group Personnel Manager,
LAPORTE INDUSTRIES, LIMITED,
Hanover House, 14 Hanover Square,
London, W.1.

E9519 A

POWER HOUSE SUPERINTENDENT REQUIRED. To supervise oil-fired B. and W. installation, 70,000 lb. capacity. Responsibilities include Air, Hydraulic, and D.C. generation and distribution. Experience in supervisory position essential, first-class B.O.T. or Naval Certificate desirable. Contributory pension scheme in operation.—Write for application form, giving age, present position and salary required, to Works Engineer, Avon India Rubber Co., Ltd., Melksham, Wiltshire. E2800 A

PRODUCTION MANAGER required for light engineering factory in pleasant rural area. Approx. 500 employees. Must be experienced in modern factory planning techniques. Practical knowledge of Sheet Metal Work, Non-Ferrous Casting, and simple Electrical Assembly an advantage. Salary according to experience, but not less than £1500.—BOX No. E9472, "The Engineer." A

RESIDENT ENGINEER (A.M.I.Struct.E.) required immediately for block of multi-storey flats for Portsmouth Corporation. To supervise foundations (piling) and erection of precast and prestressed frame and cladding. Approximately 10 months but possibility of extension. Salary £1000 per annum.—Apply in writing, stating age, qualifications and experience, to Felix J. Samuely and Partners, 231/233, Gower Street, N.W.1. E2805 A

TECALEMIT, LIMITED, PLYMOUTH, DEVON

have a vacancy for a LABORATORY ASSISTANT in the Physical Laboratory of the Research Department.

The work involves research and control on non-metallic materials such as filter media, plastics, rubber and adhesives.

Applicants should have a University degree in Mechanical Engineering or equivalent qualification with an interest in physics or technology; research experience with one of the materials mentioned and some experience in statistics as applied to planning and evaluating experimental work will be an advantage.

The finally selected candidate will find interesting and varied work in a progressive and active modern factory. His salary will be commensurate with his qualifications and experience.

The Company operates a contributory superannuation and life insurance scheme.

Applications should include details of age, education and experience, and be addressed to the Employment Officer.

E9459 A

THE GLACIER METAL CO., LTD.,

require for their London Factory

A SENIOR PRODUCTION ENGINEER

to lead a team in the examination of production techniques, development of improvements, and the installation of the developed techniques in Production. Work will range from short-term action, where immediate returns are the prime objective, to long-term development of new techniques of production lasting up to 12 months. The work will extend into all parts of the Factory, and requires an understanding of press and machine tools, of the special requirements of high-speed transfer machinery, and of Foundry and plating practice.

Requirements: Degree, A.M.I.Mech.E., or A.M.I.Prod.E., Apprenticeship or equivalent experience in methods development desirable.

Age preferred: 26-35.

Salary range: £950-£1350.

Personnel Manager (Ref. 2716/2717),
The Glacier Metal Co., Ltd.,
Ealing Road,
Alperton, Wembley, Middlesex.

E9486 A

TRAVELLING SITE INSPECTOR (A.M.I.Struct.E.), based London, required by Consulting Engineers. Experience of all types of reinforced concrete framed structures, precast and prestressed concrete, steelwork, &c. Sites in all parts of U.K.—Apply in writing, giving age, experience and salary required, to Felix J. Samuely and Partners, 231/233, Gower Street, N.W.1. E2806 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer." A

STRESS ENGINEER

DAVY AND UNITED ENGINEERING COMPANY LIMITED,

the largest producers and designers of rolling mill equipment in Great Britain, require a Graduate Mechanical Engineer with experience of stressing techniques to expand and develope an existing stress section.

He will be responsible to the Chief Engineer for the development of standard analytical approach to general design problems. This work will entail the theoretical analysis of dynamic machines and structures subjected to impact and thermal loading. Complete research facilities exist for fundamental investigations into problems encountered. These facilities include a field research team equipped to carry out stress measurement on working components and a research workshop, together with a photo elastic bench. Knowledge of heavy welded fabrication techniques would be an advantage, but is not essential.

Comprehensive amenities, Superannuation Scheme.

Apply with full details of age, experience and qualifications to:
Personnel Department, Davy and United Engineering Company Limited, Darnall Works, Sheffield, 9. E9503 A

SITUATIONS VACANT

BICC

require a

GRADUATE PHYSICIST OR MECHANICAL ENGINEER

for the Pilot Plant at their factory at LEIGH, LANCS. The work concerns the development of new electric cables and processes and provides good opportunities for inventiveness and originality. Previous industrial experience not essential, but those with a practical approach to problems are desirable. Salary according to age and experience. Staff superannuation scheme in operation.

Written applications, stating age, experience and qualifications, should be addressed to :

Personnel Officer,
BRITISH INSULATED CALLENDER'S CABLES, LTD.,
Anchor Works, LEIGH, Lancs.

E9480 A

SITUATIONS VACANT

THE HARLAND ENGINEERING COMPANY, LTD., ALLOA

require several

SENIOR DRAUGHTSMEN

in connection with an expanding development programme in the field of centrifugal pumps, hydraulic turbines and medium-large electrical rotating machinery.

Experience in these products, whilst advantageous, is less important than thorough knowledge of modern mechanical engineering, stress analysis, materials selection and application, and up-to-date draughting methods.

The Company offers good salaries and working conditions with contributory pension scheme, extended holidays after twelve months and assistance with house acquisition or purchase.

Replies, giving full particulars of age, qualifications and experience, will be treated in strict confidence and should be sent marked " Personal " to Chief Draughtsman, B.E.P. Works, Alloa, Scotland. E9495 A

SITUATIONS VACANT

PLANT ENGINEER

required by

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

to

- ★ Specify Improvements.
- ★ Plan Maintenance.
- ★ Supervise Maintenance and Other Work on new and original plant associated with PROTON ACCELERATORS.

Applicants should have served a recognised mechanical engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or have equivalent qualifications, some electrical experience desirable.

SALARY : £860 (at age 25)–£1340 p.a.

Housing and contributory pension scheme.

SEND Postcard for application form to the Group Recruitment (1648/25), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

E9497 A

SENIOR MECHANICAL ENGINEER

A Senior Mechanical Engineer is required by a Company engaged in a continuous process industry. The successful candidate will become a member of a management team connected with the management of a large factory. It is essential that candidates have :

(a) A good Degree in Mechanical Engineering.

(b) Some engineering background in heavy engineering.

This vacancy is a particularly attractive one for the right calibre person and the future holds out very good prospects. The age limit is 35. A good commencing salary is offered.

Write, stating full details, age, qualifications and experience, to BOX No. E9485, " *The Engineer.*"

A

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

BERKELEY NUCLEAR LABORATORIES

The Laboratories now under construction at **Berkeley, Gloucestershire,** on a site adjacent to the Berkeley Nuclear Power Station, will be completed towards the end of 1960 and will carry out a major part in the Board's experimental nuclear research and development programme in physics, engineering and materials.

Applications are now invited for the following posts in the **ENGINEERING DIVISION.** Persons appointed will in general work initially at the Board's office in **Bristol** and will be transferred to Berkeley as the laboratory buildings become ready for occupation.

A. Design Engineers Ref. ENR/142

Mechanical and Electrical Engineers to design and supervise the construction of rigs for development work associated with nuclear power reactors. The work covers a broad field of development, namely, physics, materials and engineering, and offers considerable scope for design ingenuity. Successful applicants will work as a team in close collaboration with physicists and metallurgists and good drawing-office facilities will be provided. Candidates should have an Engineering Degree or be Corporate Members of an Engineering Institution. They should have served an apprenticeship and have several years' experience of engineering design work, preferably in the nuclear field.

Salaries within the range £1195-£1775 p.a., according to duties and responsibilities. Vacancies also exist for engineers without direct experience in this class of work within a salary range rising to £1300 p.a., according to duties and responsibilities.

B. Development Engineers

Mechanical Engineers for development work in pressure circuit components including pressure vessels, ducting, bellow units and gas valves.

Mechanical and Electrical Engineers for development work on reactor control and instrumentation, namely, control rod drives and mechanisms, flow temperature and pressure measurement. The work will concern mainly the current gas cooled reactor programme, but some original work on different advanced systems will be encouraged. Candidates should have an Engineering Degree or qualifications leading to Corporate Membership of an Engineering Institution. They should have served an apprenticeship and have several years' appropriate experience in development work.

Salaries according to duties and responsibilities, within the range £1195-£1775 p.a. Vacancies also exist for staff with less experience within a salary range rising to £1300 p.a., according to duties and responsibilities.

C. Assistant Maintenance Engineer Ref. ENR/142C

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Classified Advts. continued on page 84

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May 3-4	**Machine tools and miscellaneous stores.**	M.O.A. Storage Depot, **Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
May 10	**Machine tools and miscellaneous stores.**	M.O.A. Storage Depot, **Byley, Nr. Middlewich, Cheshire.** (Sale at Cheetham Town Hall, Manchester, 8.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
May 17	**Vehicles, earth moving and lifting equipment.**	M.O.A. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
May 24	**Miscellaneous stores.**	Command Ordnance Sub - Depot, **Devizes.** (Sale at Corn Exchange, Devizes.)	**FARRANT, WIGHTMAN & PINNIGAR** (Dept. L), 2, Newport Street, Swindon, Wilts. (Tel.: 5151/2.)
June 10	**Machine tools and miscellaneous stores.**	Technical Stores Depot, **Old Dalby, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)

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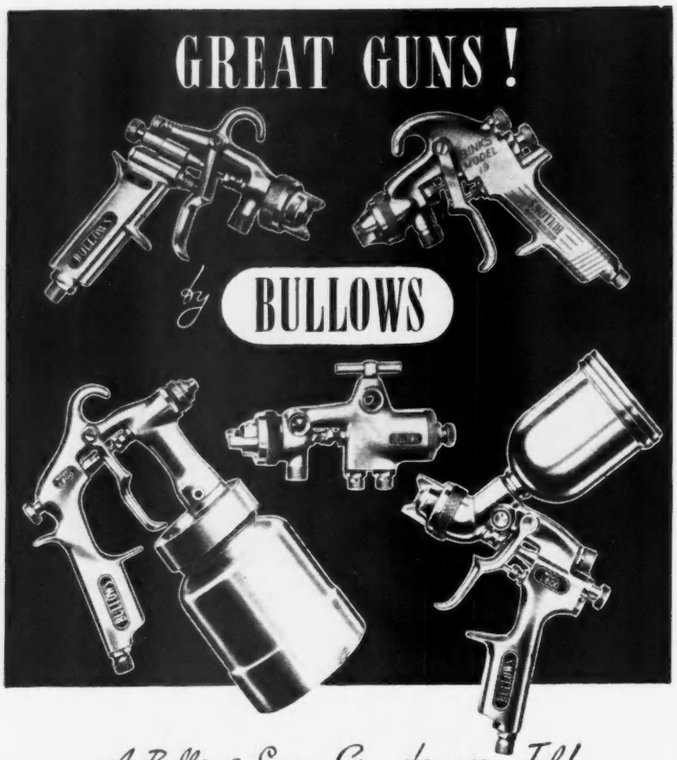

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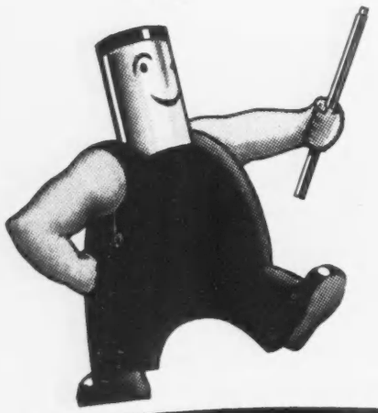

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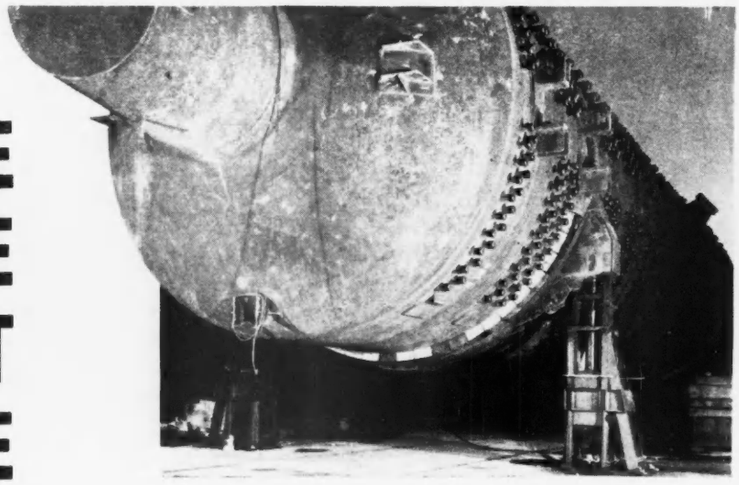

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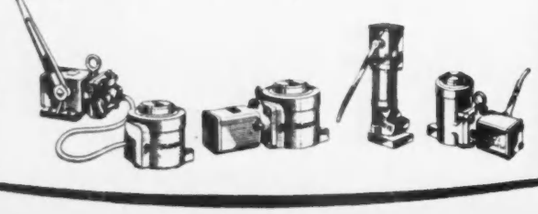

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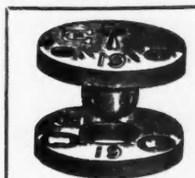

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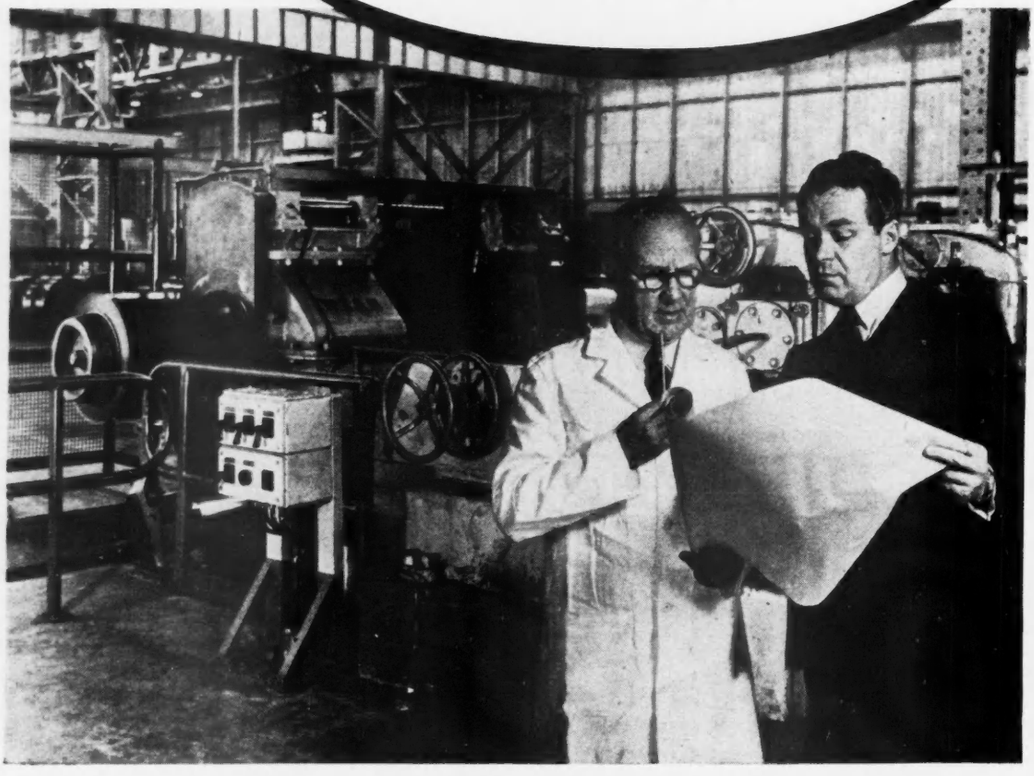

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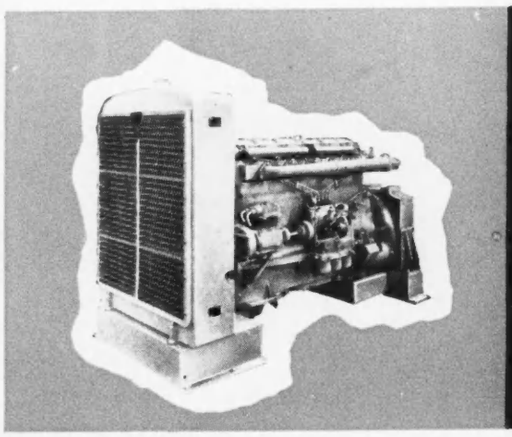

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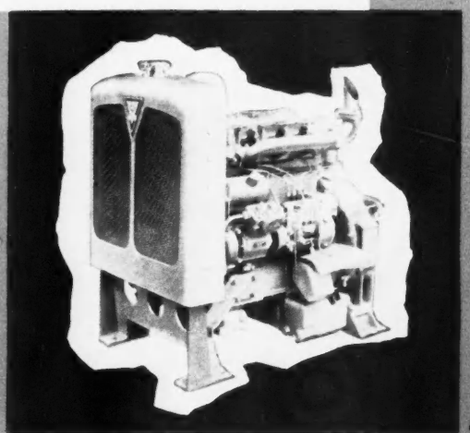

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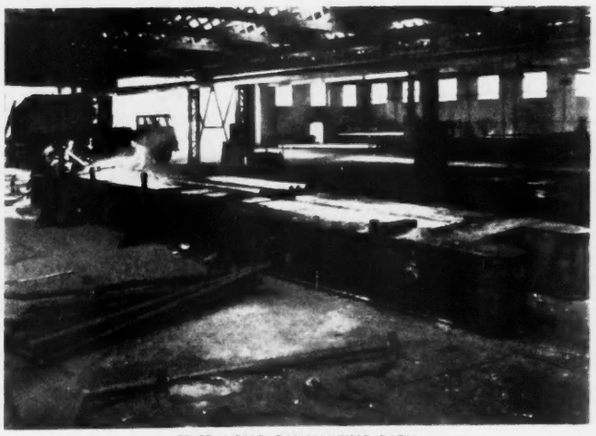

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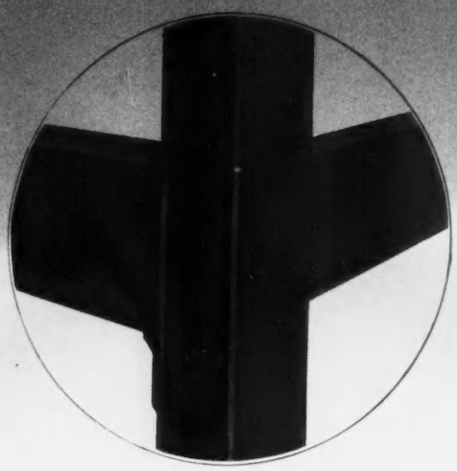

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